POWER

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A New Year Letter

Written by the supervising engineer of a public utility-company in the Middle West to engineers of different power plants under his direction.

o o o

Dear Sir—With the beginning of the new year it might be well for all of us to investigate every point about our power plant with a view to getting higher economy, if possible, in our future operation and maintenance. Below are a few questions we should ask ourselves, answering them in our own minds, not allowing the matter to drop until we are satisfied everything possible has been done and a report made out stating why certain results cannot be attained:

Are our boilers clean; is the brickwork in good condition, and are all cracks and unnecessary openings airtight?

Is the feed-water heater clean and working efficiently, and is the water as hot as possible?

In water-tube boilers, do we know that the baffling is tight and that the gases are not short-circuited directly to the stack?

Are we sure all blowoff valves are tight and that we are not blowing down too much?

Are our dampers working, and do we use them instead of closing the front doors on hand-fired boilers, allowing cold air to filter through the brickwork, etc., or, on stokers, allowing the fires to burn off the back of the grate?

Are we carrying a steady maximum steam pressure?

Are all our grates, gages, flue cleaners and other boiler auxiliaries in perfect condition?

Have the soot and ashes been cleaned out of the bases of the stacks?

Do we know that the breeching is not partially stopped up with soot?

Do we know that our draft is the maximum possible under the existing conditions?

Are we using the minimum amount of labor to properly perform the work in both the engine room and the boiler room?

Are our engines operating as economically as possible under their present conditions?

Do the pistons leak?

Do the valves leak, and are they properly set?

Is there undue drop of pressure between the boilers and the engines?

Is the steam reasonably dry?

Is the back-pressure on the exhaust a minimum?

If we are using superheaters, do we know that we have the maximum superheat?

If not, are the superheaters stopped up or dirty?

Are all steam traps in good condition, or are valve seats cut, floats collapsed or other parts defective?

Are all exposed heating surfaces properly covered?

Do we know that all valves on steam lines and all drain valves are tight?

Are all drains from oil separators, heaters, piping, etc., clear?

In plants running condensing, are we using the proper auxiliaries to keep our feed-water temperature a maximum and our motor-driven auxiliaries operating at maximum efficiency due to low temperature of the condensing water?

Are we trying to get a maximum hotwell temperature by controlling the amount of condensing water to the condensers?

Have we the maximum vacuum possible with the present temperatures, barometer and load?

Do we keep a maximum load factor on the apparatus in use?

Do we try to keep down the cost of supplies, such as lamps, oil and waste?

Do we know that our apparatus and our station light and power wiring are in safe condition?

Have we fire extinguishers on hand, and any fire hose we may have properly connected?

Have we taken all precautions to prevent accidents by protecting all openings by railings, inspecting all ladders to see that they are safe, looking after all weights or other heavy parts that may be suspended from above, and seeing to it that all pulley blocks, tackle chains and other tools are in perfect order; that there are no oily or slippery places in or around buildings; that piping or any part of apparatus in use is not showing signs of strain; that proper guards are placed around wiring, switchboards and high-tension apparatus, and that danger signs are placed where necessary?

Have we prepared for extreme weather conditions in the way of ice, floods, lightning, etc.?

Have we taken care of the effects of high winds and rains on our stacks, windows, roofs, etc.?

The whole thought of this letter is to bring out any suggestions or ideas you can put forward to improve our economy and service. If you will put in writing anything of this nature we will be glad to make every effort to get the matter attended to.

[*Written by F. W. Laas, Cedar Rapids, Ia.*]

Baltimore Sewage-Pumping Plant

By Warren O. Rogers

SYNOPSIS—This sewage-pumping plant has three 400-hp., 27,500,000-gal. pumping engines and three 260-hp. water-tube boilers. Sewage is pumped against a head of 72 ft. through 42-in. discharge pipes. Drainage water is used in the condensers of the pumping engines and is handled by engine-driven centrifugal pumps. Sewage from the Back River disposal plant is utilized to operate two 150-hp. waterwheels, each driving a 110-kw. alternating-current generator, the electrical output of which is used for lighting and motor circuits at the disposal plant.

What is regarded by engineers as the most scientific system in the world for handling sewage is the twenty-one-million-dollar sewage system now under construction at Baltimore, Md. Prior to the great fire in 1904, the city, with a population of nearly 600,000, was without a sewage system, depending on cesspools and private sewers.

Owing to the contamination by sewage of the waters of the Chesapeake Bay and the injury done the oyster industry, the legislature passed laws requiring a sewerage system and the purification of the sewage before discharging into the bay. A sewerage commission was appointed, with Calvin W. Hendrick as chief engineer, under whose direction this system was constructed and is now nearing completion.

By a series of intercepting sewers, about two-thirds of the city's sewage is carried to Back River by gravity; the rest is intercepted along the river and harbor front. Upon reaching the new pumping station near the center of the city, it is pumped against a head of 72 ft. through 42-in. iron mains for about a mile, from which point it flows by gravity to the disposal plant at Back River, some six miles east of the city.

Pumping Plant

The pumping station (Fig. 1) is constructed of brick and stone on a concrete foundation. Below the main floor the walls are of granite, and above they are of light-brown brick with terra cotta moldings. The roof is of slate, supported by steel trusses carried by steel columns built into the walls.

The building is fireproof, has an outside dimension of 188 ft. by 156 ft. 7 in., and is 59 ft. high from the ground to the top of the walls. The engine room is 180 ft. long, 54 ft. wide and 68 ft. high from the basement floor to the tie beams of the trusses. It is lined with enameled brick for 23 ft. above the basement floor.

At present there are three triple-expansion, crank and flywheel, condensing pumping engines (Fig. 2) having 22, 42 and 62 by 60-in. steam cylinders. These units run at 20 r.p.m., each having at this speed a capacity of 27,500,000 gal. of sewage every 24 hr., or a total of 82,500,000. The horsepower of the engine is 400 at normal speed, with 175 lb. steam pressure, and operating with a 28-in. vacuum. The first receiver pressure is 32 lb. and the second receiver has a pressure of 2 lb. gage. These pumping engines rest on concrete foundations separated from the building so as to absorb any vibration.

The boiler room is separated from the engine room by a screen chamber below the main floor level and a machine shop and storeroom on the main floor level. The boiler room is 94 ft. long by 50 ft. wide, with space for five 260-hp. water-tube boilers set separately; at present there are but three 260-hp. boilers (Fig. 3). Each has two steam drums 23 ft. 3⅝ in. long and 36 in. diameter, made of $\frac{7}{16}$-in. plate. The tubes are 18 ft. long and 4 in. diameter. The heating surface of the drums is 193 sq.ft. and that of the tubes 2473, a total of 2666 sq.ft.

Two of these boilers are estimated as having sufficient capacity to supply steam for the three pumps. One boiler only is under pressure now, and it supplies steam for the pump that handles the sewage at the present time. The spare boiler is held to take care of fluctuations in the sewage. Each boiler is capable of supplying steam for one pumping engine and all auxiliary machinery.

The boilers are hand fired and have a grate area to heating surface of 1 to 44.4. The furnace gases pass to an economizer above the boilers having 1550 sq.ft. of heating surface; it heats the water from the main pump feed-water heater from about 90 to 160 deg.

All the boilers are connected to a single brick chimney 200 ft. high above the boiler-room floor; it has an inside diameter of 10 ft. at the top. It is lined with firebrick for half its height and rests on a concrete foundation. The draft is controlled by a damper regulator which operates a main damper between the boiler and the stack. Each boiler has a connection to a CO_2 recorder. One boiler is equipped with a superheater.

The boiler feed water is metered, each boiler having a separate meter and a differential draft gage. Feed water is handled by either of two 6 and 3¼ by 6-in. pot-valve outside packed duplex pumps back of the boilers. Coal is delivered to the plant in barges and unloaded by a grab bucket into a hopper which delivers the coal to a bucket conveyor, and then into any one of the five 200-ton bins above the boilers. The conveyor also carries the ashes from the basement to an ash bunker at the top of the boiler room, where they are loaded into wagons for removal. Fig. 4 shows the bucket conveyor in the basement.

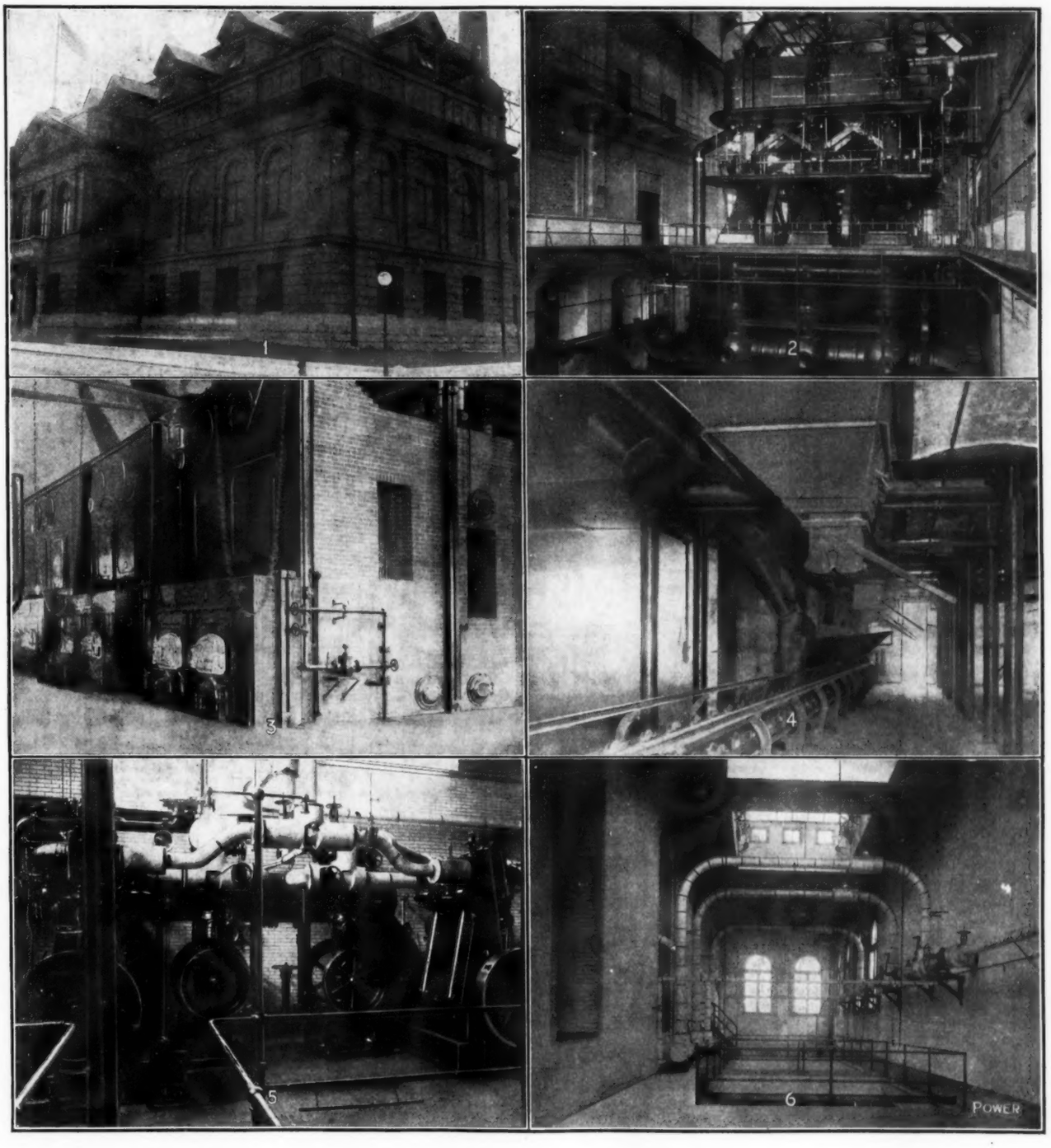
At one end of the pump room are two 40-hp. centrifugal pumps driven by 7 and 14 by 8-in. compound condensing engines. Each pump has a capacity of 3000 gal. per min. and draws water from underdrains below the interceptors, and discharges either through the condensers of the main pumping engines or to the harbor direct. These engines (Fig. 5) each drive an air pump by a noiseless chain drive. At the same end of the building there is a 35-kw. 7 and 13 by 8-in. compound engine-driven generator set delivering current at 250 volts, at 300 r.p.m., for station lighting and motor circuits. There is also a smaller generator driven by an 8x7-in. vertical engine, and a small motor-driven air compressor, used to supply air for operating the exhaust valves on the low-pressure cylinder, at from 28 to 30 lb. pressure.

Screen Chamber

In the basement, between the pump and boiler rooms, is the screen chamber, and below its main floor is a

reservoir into which the sewage is discharged from the interceptors and then drawn by the pumps. All sewage is screened twice, first through a set of movable screens at the entrance to the screen chamber and then through a fixed screen over the suction pipes of the pumps. The movable screens catch the coarser materials, which are hoisted out, the water with which they are saturated is removed in a steam press, and the screenings are then burned in a special furnace in the boiler-room basement.

Above the screen chamber, level with the pump-room floor, are toilets for the engineer and firemen, a machine shop large enough to do ordinary repairs, and a storeroom. Above these is a header room (Fig. 6). The steam piping between the boilers and pumping engines is so arranged that no single accident can put more than one boiler or pumping unit out of service. On the boiler-room side of the header room is an 8-in. main header which reduces to 4 in. at the ends. This header is held



VIEWS OF THE BALTIMORE PUMPING STATION

Fig. 1. Exterior of the Baltimore sewage-pumping station. Fig. 2. Pump room, containing three 27,500,000-gal. capacity pumping engines. Fig. 3. Three 260-hp. water-tube boilers. Fig. 4. Coal and ash bucket conveyor. Fig. 5. Engine-driven centrifugal circulating pumps. Fig. 6. Header room between boiler and pump rooms.

in place by brackets secured to the side wall about 12 ft. above the floor. On the opposite side of the room, near the floor, a duplicate 8-in. header is piped to the opposite header by three 5-in. long-radius bent pipes. The pipe connections between the second header and the pumping engines are 5 in. in diameter. A duplicate set of auxiliary pipes runs from the headers to the auxiliary units in the pump-room basement. Both headers are dripped to a separate drip line and the water of condensation returned to the boilers. The plant is operated by F. H. Cronin, chief engineer.

Sewage from the pumping plant is discharged into the main sewer at a point where it will flow by gravity to the disposal plant at Back River. Here there are three hydrolytic tanks, three sludge-digesting tanks and 18 acres of broken-stone sprinkler filters, together with two settling basins. There are in process of construction 28 Imhoff tank units, 16 sludge-digesting tank units, with accompanying sludge beds, and 12 additional acres of broken-stone sprinkling filters.

As the sprinklers are 15 ft. below the hydrolytic tanks, a head is obtained sufficient to spray the sewage over the stone beds through nozzles spaced 15 ft. apart. The hydraulic head is controlled by butterfly valves which cause the sprays to rise and fall, varying from close to the nozzles out to the limit of 15 ft., thus utilizing uniformly all of the surface of the stone bed as the nozzles throw a square spray.

All spray falls on the beds and trickles down through 8½ ft. of broken stone, coating the stone with a gelatin-like film in which certain bacteria multiply by millions and attack and kill the injurious bacteria in the sewage. When the sewage reaches the bottom of the filtering beds it is practically pure. It then finds its way to a central passage under the beds and is delivered to the settling chambers, requiring three hours for its passage. The sewage then drops 18 ft. through either of the two 150-hp. waterwheels in the power house.

The power thus obtained is used to operate two 110-kw., 60-cycle, three-phase, 2300-volt alternating-current generators (Fig. 7), at 276 r.p.m. The two 7½-kw., 125-volt exciters are each driven by a noiseless chain belt at 1000 r.p.m.; the speed of the generators is regulated by two belt-operated hydraulic governors. The output of these two generators is utilized for illuminating the disposal plant and for operating small motors. To insure against interruption of service, an 85-hp. gas engine is coupled by a clutch to one of the generators so that if there is not enough water to operate the unit the engine can supply the power. It runs at 276 r.p.m. and has three 10½x16-in. cylinders.

At one side of the room is a motor-driven centrifugal pump with a capacity of 600 gal. per min. against a head of 157 ft., at 1750 r.p.m. This pump forces water into a tank and is used for washing out the hydrolytic tanks and for general flushing purposes.

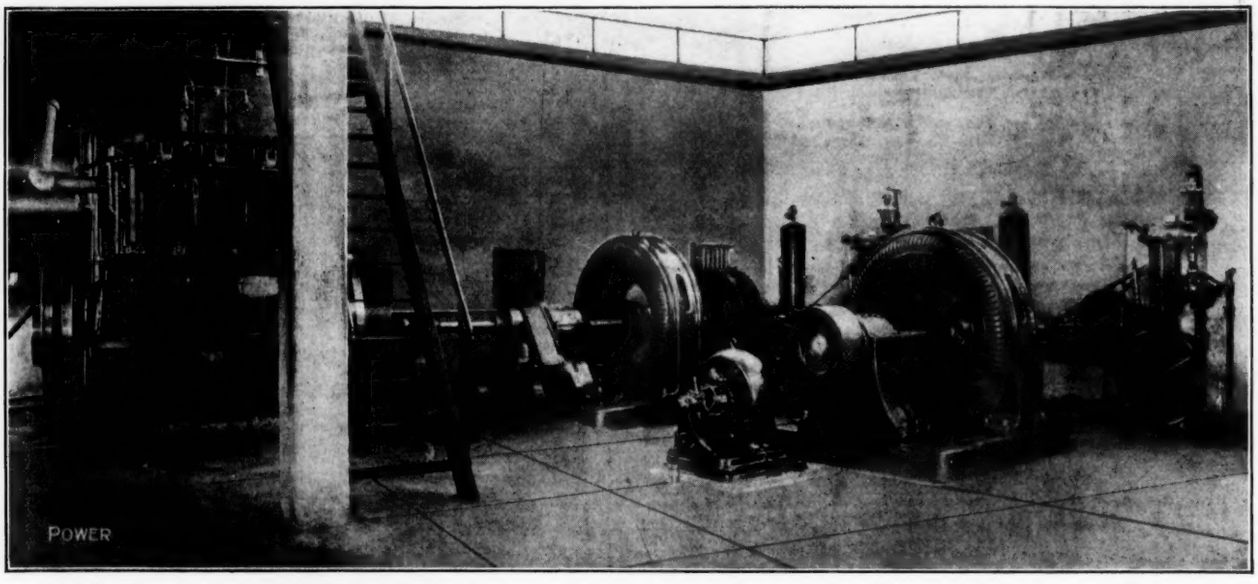


FIG. 7. GENERATING PLANT AT THE BACK RIVER DISPOSAL PLANT

PRINCIPAL EQUIPMENT OF THE BALTIMORE, MD., SEWAGE PUMPING AND DISPOSAL LIGHTING PLANTS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Pumping engines	Triple expansion	22x42x62x60 in.	Pumping sewage	20 r.p.m., 27,500,000 gal. capacity, 72 ft. head	Bethlehem Steel Co.
3	Boilers	Water tube	260 hp.	Steam generators	165 lb. steam	Babcock & Wilcox Co.
1	Economizer	Green	1550 sq.ft.ht. surface	Heating feed water	Water raised to 160 deg.	Green Fuel Economizer Co.
3	Gages	Draft		Furnace draft		Lewis M. Ellison
1	Regulator	Damper		Draft control	Automatic	Locke Regulator Co.
1	Recorder	Uehling CO_2		Determining per cent. CO_2		Uehling Sales Co.
2	Pumps	Duplex	6x3½x6 in.	Boiler feeders	165 lb. steam	Epping Carpenter Co.
1	Superheater	Foster		Superheating steam		Power Specialty Co.
2	Pumps	Centrifugal	12 in.	Drainage	Engine driven	Lawrence Machine Co.
2	Engines	Vertical compound	7x14x8 in.	Driving drainage pumps	Steam 165 lb.	Lawrence Machine Co.
2	Pumps	Edwards air		On condensers	Chain belt driven	Wheeler Condenser & Mfg. Co.
1	Engine	Compound	7x13x8 in.	Driving 35-kw. generator	165 lb. steam, 300 r.p.m.	Trenton Engine Co.
1	Generator	Direct current	35 kw.	Engine driven	300 r.p.m., 250 volt	Fort Wayne Elec. Works
1	Engine	Single	8x7 in.	Driving small generator	165 lb. steam, 400 r.p.m.	Trenton Engine Co.
1	Generator	Direct current	15 kw.	Engine driven	400 r.p.m., 250 volt	Fort Wayne Elec. Works
1	Motor	Direct current	2 hp.	Driving compressor	1350 r.p.m., 220 volts	Allis-Chalmers Co.
1	Compressor	Christensen		Compressing air	Motor driven	Christensen Engineering Co.
2	Turbines	Water	150 hp.	Driving generators	18 ft. head, 276 r.p.m.	S. Morgan Smith Co.
2	Generators	Alt. current	110 kw.	Power and lighting circuits	276 r.p.m., 3 phase, 60 cycle, 2300 volts	Fort Wayne Elec. Works
2	Generators	Direct current	7½ kw.	Exciters	1000 r.p.m., chain drive, 125 volts	Fort Wayne Elec. Works
1	Engine	Vertical, gas	85 hp.	Driving a. c. generators	276 r.p.m.	National Meter Co.

The Hot-Bulb Oil Engine

By Edwin Lundgren

SYNOPSIS—Description of the important details and points which the designer has to consider, with data gained from practical experience.

The oil engine with hot-bulb ignition is a type that has been developed widely during the past ten years, and which has gained a large field of application in Europe, particularly for marine and for agricultural purposes. Of course, the main condition for commercial success is rational management and good shop methods, but the design of the product is just as important. The paramount requirement is a reliable engine, as nearly foolproof as possible, and of simple construction. The two-stroke-cycle type appears to have proved simpler and more economical than the four-stroke-cycle engine with hot-bulb ignition; therefore, this type will be selected for discussion.

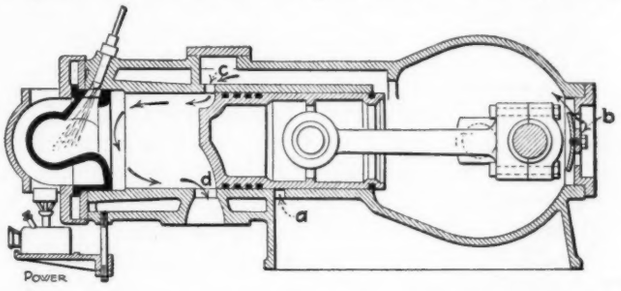


Fig. 1. Typical Two-Stroke-Cycle Hot-Bulb Engine

Reference to Fig. 1 will make clear the principle of this engine. Air is sucked into the crank chamber by the piston, either through ports *a* in the cylinder wall or through a simple air valve *b*; it is then compressed in the crank chamber and led through a bypass and ports *c* into the cylinder, where it is deflected by the piston and expels the exhaust gases through the ports *d*. The cylinder is now filled with air; not pure air, of course, as the quantity admitted is not large enough to scavenge perfectly and as the nature of the process makes perfect cleaning of the cylinder impossible. This mixture of pure air and burnt gases is compressed by the piston on its return stroke, and at 50 to 85 per cent. of its travel, the fuel—kerosene, fuel oil or crude oil—is injected through a fine spray nozzle directly into the heated vaporizer or hot-bulb head. At about dead-center spontaneous ignition takes place, an explosion and combustion follow, and the piston is driven forward on its working stroke until it uncovers ports *d* and then *c*, whereupon the cycle is repeated.

The typical indicator diagram of Fig. 2 illustrates the process within the cylinder, showing the compression to be fairly high, varying in different designs from 90 to 110 lb. per sq.in. The explosion pressure may reach 300 to 350 lb. per sq.in.

Considering the relative merits of three-port and two-port engines, it may seem at first that the three-port is the simpler and better, but the reverse is true, as the two-port engine requires a simpler casting. Also, for lubricating, it is better to avoid the third port, and the two-port engine gives a little more power. For smaller sizes it is advisable to cast the cylinder and frame in one piece, and the saving in machinery will offset the higher cost of casting. One of the most important parts is the cylinder head and vaporizer or bulb. Figs. 3 to 6 show different types which have been used successfully. The clearance volume is $\frac{1}{4.5}$ to $\frac{1}{5.5}$ of the stroke volume according to the compression desired. The walls of the vaporizer, which are usually cast iron but sometimes cast steel, have to be made fairly thin, otherwise too much time will be required to heat it for starting.

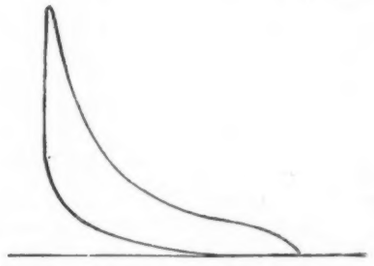


Fig. 2. Indicator Diagram from Two-Stroke-Cycle Hot-Bulb Engine

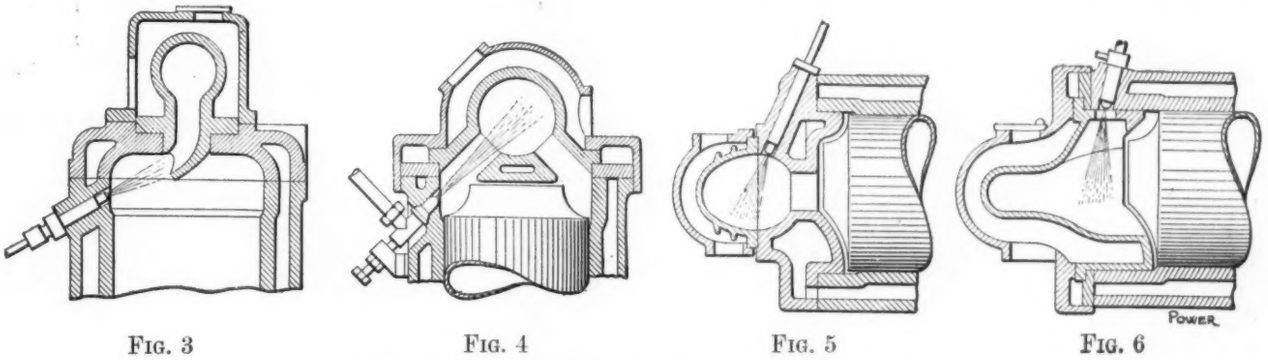


Fig. 3 Fig. 4 Fig. 5 Fig. 6

Different Arrangements of Hot-Bulb Ignition

Against the walls of this heated vaporizer the fuel is sprayed in a fine mist. The proper formation of this spray, however, requires experience. If it is too fine, preignition will occur, whereas if it is too coarse, combustion will not be good, and high fuel consumption will result.

A good nozzle construction is shown in Fig. 7. After passing through one or two check valves the oil is led through the spiral grooves and the fine hole at the point of the nozzle, the size of the hole and the depth of the grooves exercising a decided influence upon the formation of the spray.

Of course, the action of the fuel pump is also important. It must have a quick, short stroke, and as the fuel for each revolution has to be forced through a fine hole within a fraction of a second, the pressure must be very high; the writer has measured it to 800 lb.

A typical construction of fuel pump and governor is shown in Fig. 8, the design being simple and self-explanatory. The steel plunger is ground in the brass body of the pump. Sometimes a packing is not provided, although it is to be preferred. If used, it should not be tightened enough to hamper the return stroke of the plunger, which is produced by the spiral spring. The stroke can be varied by shifting the block *a*, and the pump

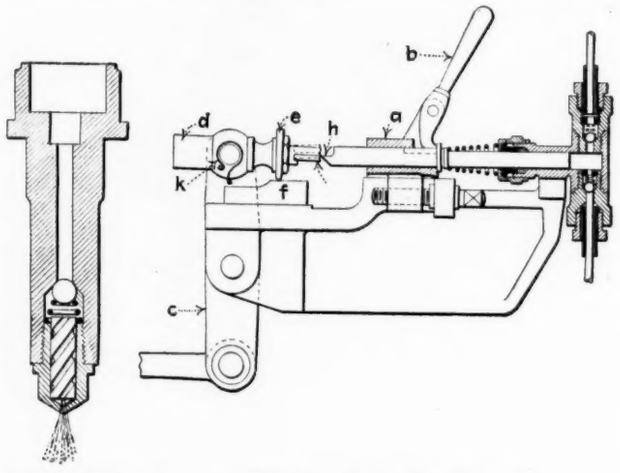


FIG. 7. FUEL NOZZLE

FIG. 8. FUEL PUMP AND GOVERNOR

can also be actuated by hand through the lever *b*, which is necessary when starting.

The simplest governor is the "hit-and-miss" type and for most purposes it is sufficient. In Fig. 8, the lever *c* receives its motion from a cam or an eccentric. To it is attached a lever *d*, which carries a square fiber disk *e*, and by means of a spring *k* is pressed down on block *f*. Usually the disk *e* just slides back and forth on the block, but if the speed increases, the lever with the fiber disk, due to inertia, jumps too high when it leaves the little incline shown, and thus its edge *g* misses the edge *h* of the push-rod. In this manner the speed can be kept within narrow limits when changing from full load to no load, and it can be adjusted by changing the tension of the spring *k* or by shifting the block *f*.

The speed also can be controlled by a flywheel governor, which changes the stroke of the fuel pump or keeps the suction valve open during part of the pressure stroke. As an alternative, an ordinary centrifugal governor may be employed which acts in a similar manner, or which shifts a cam that in turn gives the pump a different stroke.

A weak point with many engines of this type is the injection of water into the cylinder. This is necessary for heavy loads as otherwise preignitions will occur. On the other hand, water should not be admitted when the engine is running idle or at light loads, for it will misfire and possibly shut down. The water retards combustion and effects cooling. The effect of water injection is shown in the indicator diagram, Fig. 9, where purposely a little too much water was admitted. Usually, the water

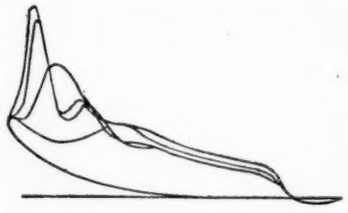


FIG. 9. SHOWING EFFECT OF WATER INJECTION

is admitted in a rather crude way, through a needle valve into the bypass, from which it enters the cylinder with the air. In this case continuous attention has to be paid to the needle valve to regulate the amount of water. If the load is fairly steady, no attention is required, but with a varying load it is inconvenient. Therefore, in several designs the water is injected by a small pump under the influence of the governor, thus giving more or less water to suit the load.

With a view to eliminating the necessity for water injection, the writer once built an engine having a flywheel governor that turned the pump-actuating eccentric so that with light loads the injection took place at the usual time, but at heavy loads so late that no preignition could occur. The engine worked all right, but experience has shown that even here water injection proved advantageous, as it increased the power.

Of prime importance also are the dimensions of the ports for the air inlet and the exhaust, which depend largely on the size and speed of the engine; the greater the speed, the larger the ports, although in larger engines the ports can be made relatively smaller. On an average, the length of the exhaust ports is 20 to 22 per cent. of the stroke, and that of the inlet ports 9 to 13 per cent., while they occupy about 90 deg. on the circumference. The exhaust ports should be uncovered so early that the pressure in the cylinder is almost nil when the

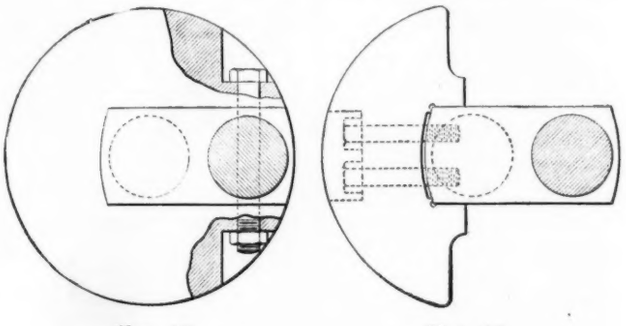


FIG. 10 FIG. 11

WRONG AND PROPER DESIGNS FOR COUNTERWEIGHTS

inlet ports open, for only in that case can effective scavenging be obtained.

The pressure of the scavenging air is not high, about 4 to 5 lb. per sq.in., but it is enough to blow the air and oil out of the crank case through every possible opening, particularly around the shaft. In small engines this does not amount to much, for the bearing is usually a straight cylindrical bushing, and if sufficiently oiled, does

not let any air escape. Sometimes a steel disk is placed on the shaft, the idea being that the side of this disk, in contact with the bearing, will keep tight enough even if the bearing wears down a little. In other cases disks are employed which do not rotate but which are pressed by springs against the crankshaft, making a good joint. In still another arrangement a cast-iron ring is sprung into the bearing.

In order to make the pressure in the crank case as high as possible and render the crank case efficient as an air pump, the clearance must be kept as small as possible. A long stroke is therefore not advisable. The importance of the clearance is, however, often overrated as it does not pay to make a counterweight such as that in Fig. 10; Fig. 11 is a better design. The writer once tried several engines with and without counterweights and marked difference in power was not noticeable.

In a horizontal engine the counterweight is necessary, for otherwise too strong vibrations will occur. While a counterweight like that in Fig. 11 is best, it is cheaper

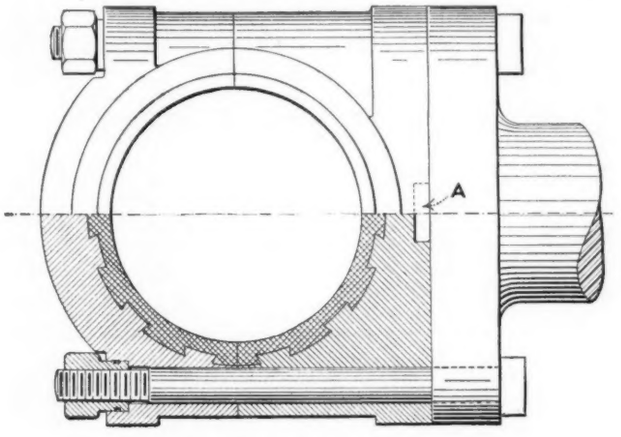


FIG. 12. CONNECTING-ROD END

to cast one in the flywheel. However, it is not to be forgotten that such a weight revolving at high speed will cause additional stress on the main shaft. The main parts of the crank mechanism offer no extraordinary features, and are usually computed, assuming an explosion pressure of 300 lb. per sq.in. For determining bearing surfaces a lower value can be used—about 250 lb.

The connecting-rod should be so designed that an adjustment of its length can easily be made, the marine head, as shown in Fig. 12, being recommended. The head should be as small as possible, so as not to make the crank chamber too large. Often the dimension *A*, Fig. 12, is too small, for it must be remembered that sometimes rather violent knocks occur which are hard on the material. Ample clearance (⅜ to ½ in.) should be provided where rough cast-iron surfaces are concerned.

For lubricating the main bearings ring oilers are preferable. A system of force feed is really the best, but it is more expensive and requires more attention. With forced feed the castings are simpler than for ring oiling. Although the performance of this type of engine is not as good as the high-compression or Diesel type, the high economy of the latter is offset by the many complicated parts, which make the small sizes prohibitively expensive. For these small sizes (2 to 50 hp.) the type described has proved reliable and economical.

Safety-Valve Specifications

BY A. B. CARHART

The specifications concerning safety valves in the proposed boiler code, as recently revised by the committee of the American Society of Mechanical Engineers, are of special importance because they express briefly and clearly all of the details concerning safety valves that were discussed and unanimously agreed upon at a conference held in Boston a few weeks ago, at which nearly all the safety-valve manufacturers of this country were represented. These specifications, therefore, may be regarded as representing the best modern practice, for they embody the combined experience and judgment of those who have had the best opportunities for the study of the subject; and as nothing at that conference was adopted without unanimous assent, the provisions must be regarded as safely conservative and proper.

The paragraphs concerning common lever valves are of little present importance, in view of the recommendation that all other than modern pop safety valves should be replaced as soon as possible.

An item of special interest in paragraph 19 is the requirement that each boiler carrying a pressure over 15 lb. and requiring a valve larger than 3 in. must have at least two safety valves. This does not mean duplicates, but that the total requirements shall be divided into smaller units. It insures greater safety and better operation of the valves and boiler. It is not likely that both valves would ever be inoperative at the same time. Safety valves are calculated to discharge the maximum steaming capacity of the boiler under extreme conditions, and each time a single large valve opens it will discharge steam at a rate much greater than generated under normal conditions. This sudden discharge is wasteful, and the pressure will drop more than necessary before closure. To avoid this, safety valves are often adjusted to blow down only one or two pounds and operate with unreasonable violence, causing destructive hammering in the valve and a considerable shock to the boiler when the large outflow of steam is suddenly checked, which in effect produces a miniature explosion every time the valve opens.

Under ordinary conditions a small valve, operating very gently, would afford adequate relief and it requires much less attention than a larger one. The second and third valves would not open unless the pressure should continue to rise, but would be in reserve as emergency protection two or three times greater than required under normal conditions.

Under paragraph 20, additional safety-valve protection is required on low-pressure boilers, because the rate of flow through the same orifice is less at the lower pressure.

In paragraph 21, an entirely new maximum evaporation calculation has been adopted. Modern conditions, with stokers and forced draft, show fuel consumption much greater for a given grate area than formerly, therefore the new formula and table proposed by the A. S. M. E. seem much more logical.

Paragraph 24 requires that valves shall be of the direct spring-loaded "pop" type. Prior to 1875, all valves, and since then some valves, have been made that are spring loaded, but do not have the pop feature.

For low steam pressure such valves serve fairly well, but their chief defect is that they open only slightly when the steam pressure reaches the set limit, and do not

lift higher as the pressure increases except by some special device. This consists of an addition to the disk excluded from the pressure of the steam when the valve is closed, but when the valve opens, the steam acts upon the additional area also and causes the valve disk to suddenly rise more than it would by the pressure upon the original area only.

The table on page 36, paragraph 21, fixes the normal steam discharge to be expected of each commercial size of safety valve at the several pressures given. It is required in paragraph 22 that all valves must show lifts and discharges at least equal to the values given in the table, when the blowdown in boiler pressure is regulated to the amounts specified in paragraph 30. It is further provided that the discharge rating of a safety valve, for the purposes of calculating the number and size of valves necessary for a boiler, shall not be greater than the values given in the table. This embodies the unanimous agreement of all manufacturers at their recent conference, following a long discussion of this special topic.

The requirement in paragraph 27 that safety valves must be attached directly to the boiler without intervening pipe or fitting or internal dry pipe, and upon a separate outlet independent of any other steam connection, has perhaps aroused more comment and criticism than any other in these specifications; yet in the judgment of those having the greatest experience and special knowledge of the subject, this is probably the most important requirement. All of the valve manufacturers were unanimously for this provision in its present form.

The provision in paragraph 25 that the several valves on the boiler should be set to open at pressures at least 3 lb. or 5 lb. apart seems proper. To set several valves on the boiler to open at nearly the same pressure is a mistake, because ordinarily the amount of steam to be discharged is much less than any one of the valves alone could properly take care of. Two or three valves opening intermittently will involve much damage to themselves and harm to the boiler.

Paragraph 30, as to the proper amount of blowdown in pressure for which the valves should be adjusted to close, is the result of the experience of all of the safety-valve manufacturers. Close regulation is harmful, generally resulting in sharp and violent action of the valve in opening and closing, shortening its useful life and unduly straining the boiler.

The purpose of the lifting gear specified in paragraph 31 is simply to afford some means of insuring that the valve disk is free and that its action is not interfered with by deposits of boiler scale or lime in the valve guides.

Paragraph 36 specifies that safety-valve springs shall withstand a cold compression test without showing any permanent set. This is to avoid dangerous consequences if the spring is screwed down to hold the valve closed during a boiler test. That such practice is entirely wrong is recognized in paragraph 40, which specifies that a test clamp or gage shall be used to hold the valve disk upon its seat during such a test.

There is also a provision that a spring shall not be used for any pressure more than 10 per cent. above or below the working pressure for which it was designed. That valves will not operate properly and will not give normal lift or blowdown when the springs are either too weak or too stiff is not always recognized.

Paragraph 39 provides that at least one safety valve shall be connected near the outlet of a superheater to insure a circulation of steam through the superheater, to protect it from harmful rise of temperature in case the normal demand for steam is suspended for any reason. Valves smaller than the 3-in. size are recommended for this service, as they are more easily maintained and kept tight. Paragraph 41 provides for standard flanges for each valve size.

The following joint letter was forwarded to the Council of the A. S. M. E., on Nov. 11, 1914:

We, the following safety-valve manufacturers, have carefully examined the third edition of the preliminary report of the Special Committee on the Construction of Steam Boilers, with particular reference to the specifications applying to pop safety valves, and are all agreed that these embody just what was unanimously accepted by the valve manufacturers who were in conference on Oct. 2, 1914. We therefore respectfully urge that your body accept and approve of same without modification, aside from such typographical errors as may be found therein.

Elevator-Rail Greaser

A device which will lubricate continuously and automatically the guide rails of the car and counterweight of an elevator has recently been perfected. The apparatus

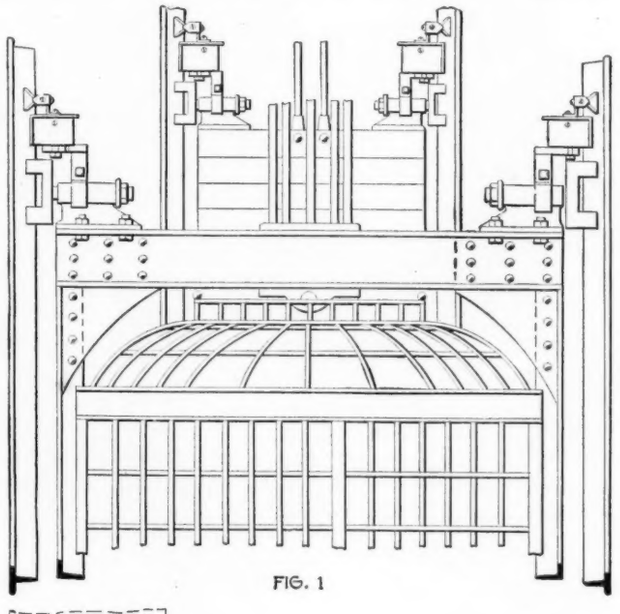
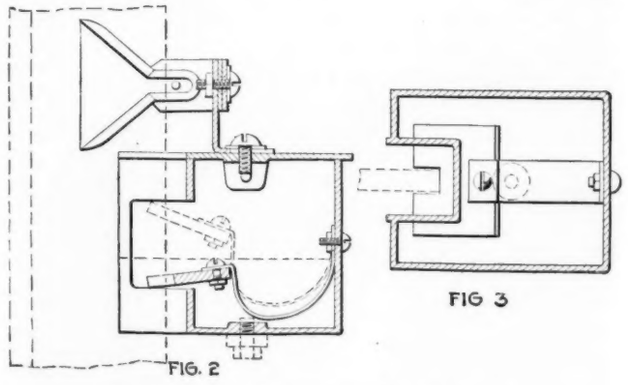


FIG. 1



DETAILS OF ELEVATOR-RAIL GREASER

is shown in the accompanying illustrations. It consists primarily of a box to hold the grease, which has a U-shaped recess so that it may straddle the web of the rail.

Through an opening in this recess a double-ply leather wiper projects. It is notched to fit the rail and, being attached to the wall of the box by a flexible spring, is free to move vertically. When the car is going up, the leather wiper is in the position shown by the full lines in Fig. 2. The dotted lines show its position for a downward movement of the car. The spring also tends to push the leather forward against the rail.

The box is filled with an even mixture of grease and graphite of the proper consistency to flow to the rail when it is agitated by the movement of the leather and spring. The greaser is attached to the top beam of the car or counterweight (Fig. 1). The feed of the grease is varied by moving the box toward or away from the rail. To remove any excess grease from the rail and drop it back onto the leather a double-bladed scraper straddling the rail is mounted on top of the box. The blades are adjustable for varying widths of guide, and in or out adjustment is permissible as they are secured to the top of the box by a screw passing through a slot.

When supplied, the box is filled with grease. At the end of six months the level of the grease is usually lowered to a point from which it cannot reach the rail. About half a pound of grease is needed to refill the box, and it is claimed that the device is then ready for another six months' service. The cover may be removed by loosening three screws which pass through the casing of the box into lugs projecting down from the cover. With this arrangement it is not necessary to remove the screws entirely and thus run the risk of dropping them into the elevator well.

Results of tests conducted on electric elevators equipped with these rail greasers show a reduction in starting torque of from 10 to 25 per cent. over dry and hand-lubricated guides. Other advantages claimed are savings in shoe and rail, the elimination of jars and jerks common to an elevator guided by dry rails, noiseless operation and no dropping of oil or grease to the floor of the well. The upkeep is small as the only part subject to wear is the leather wiper. This lasts for a long period and may be renewed at a cost of a few cents. The leather is made in sizes to conform with rails having face measurements from ½ to 9 in. W. A. Garvens, 708 South Ashland Blvd., Chicago, is supplying this device.

An American Engineer in Cuba

By Frank E. Small

SYNOPSIS—Impressions of an American operating engineer sent to Cuba to put some run-down plants in safe and economical condition.

The writer hopes that none will construe the substance of the following to be a slap at all engineers in care of Cuban plants.

On going to Cuba as a trouble man one feels that the island has grown in plants faster than it has in engineers competent to care for them. There are many good men, to be sure, but many are unfit. This condition among engineers is aggravated by the unfavorable attitude of the owners or employers toward skilled labor. Cuba is of course warm, and ice and refrigeration plants become more numerous as industry grows. Some business houses have failed owing to unnecessarily high operating costs. Some of these plants are quite old, five to ten years, and the equipment has greatly deteriorated or become obsolete. To convince the owners that they should first hire a good engineer at double or triple the usual local salary, and should immediately spend money for new equipment when they are already losing money, is difficult.

The writer has found plants which, when new, produced six tons of ice for one ton of coal, although at the time of his visits they were getting but one to two tons per ton of coal. Some plants in other industries are just as bad.

At one plant a locomotive-type boiler was set in brickwork. This seemed new and led to an inquiry as to why the brick setting was used. The engineer informed us that the firebox had been patched so many times that it was deemed advisable to set the boiler in brick, putting the furnace under the back of the boiler to reduce the temperature in the firebox.

The first look into the furnace of a horizontal return-tubular boiler in this plant showed water running from around the edges of a 24x48-in. patch, the second one to be put on that crown-sheet. The writer threatened to leave if permission was not given to reduce the pressure to 80 lb. (it was 100 lb.). This seemed to create considerable laughter in the office, but when the manager was shown that that patch was carrying a load of over 115,000 lb. he began to congratulate himself on being alive.

For some reasons the boilers here had their gage-cocks removed, gage-glasses being depended upon for showing the levels. The differences between the readings of any two steam gages was so great that for safety's sake it was necessary to immediately learn the correct pressure.

A steam hose had been used to clear the tubes of soot, and although the front ends were clear enough, the back ends contained soot that had accumulated and baked on. A brush could not be pushed through the tubes.

On the way to one plant the first day, the engines could be heard pounding before the writer was within a block of the plant. Notwithstanding this condition, the engineer was as contented as could be. This plant was but four years old, although one would take it for fifteen were it not for the modern equipment.

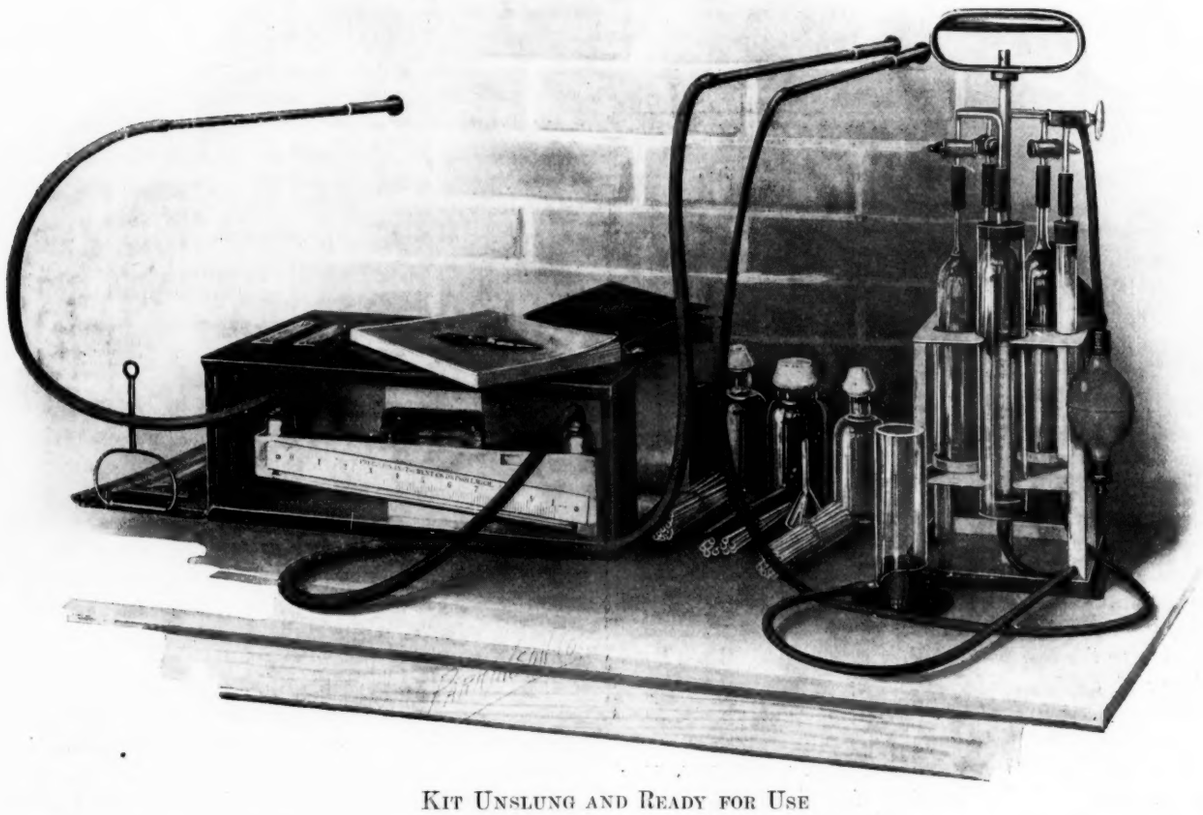
The writer's experience leads him to believe that owners should, for a time at least, receive more support from builders. Equipment is installed and operated until accepted, but in many cases it is necessary to "break in" the purchasers' engineers, and this is by no means done thoroughly. There are few competent men available, and consequently it is but a short time until the equipment is giving poor service and the builder's reputation with the local owners is injured. The builder would do well to try to get a good man to care for the plant.

At present plants here are not so much in need of men who can obtain economical results, although these must follow, as of men who can keep equipment running well.

Boiler Efficiency Kit

In checking up boiler efficiency it is essential to analyze the flue gases and take temperature readings as they leave the boiler. It is also desirable to note the draft at the fire and the drop in draft between the furnace and the damper, as these factors determine the air supply. When these data are known it is possible to calculate the combustion efficiency.

A convenient and complete kit of apparatus for obtaining the above mentioned data is being supplied by the Precision Instrument Co., Detroit, Mich. The equipment is neatly arranged in a case. The illustration shows the various devices in position for testing a boiler. The case is divided into three compartments, but by an ingeniuos arrangement the covers to all three compartments are locked by a small padlock within the handle of the case. A differential draft gage is contained in one compartment, the middle chamber contains an Orsat apparatus of special design and the third space a high-temperature thermometer, a special printed report pad for recording the various test data, some rubber tubing, etc.



KIT UNSLUNG AND READY FOR USE

As indicated, the draft gage is arranged so that both the draft in the furnace and the drop in draft between furnace and damper may be conveniently taken. For this purpose rubber tubing of suitable length and sectional iron pipes of the fishpole variety are provided. The draft gage is graduated in hundredths of an inch. For compactness the three pipettes and the burette of the Orsat are arranged in a circle. The analyzer is graduated to read in tenths of one per cent. The necessary rubber tubing for the analyzer is furnished.

The high-temperature thermometer is encased in a brass tube to prevent breakage and is provided with sectional extension pieces so that it may be inserted through any ordinary wall of a boiler setting. In the compartment containing the thermometer there is space for storing tubing, data pads and bottles containing the chemical mixtures.

The kit is also provided with a book of instructions and manual of testing methods, a pad of standard test-report blanks, proper chemicals for absorbing CO_2, O and CO, already mixed for use, a funnel, and in short, all the necessary parts and materials required to conduct a boiler-furnace efficiency test. That all of this equipment can be kept in a small, compact case ready to be carried to the point of immediate use is an advantage.

Some Original Ideas

An operator complained of the rapidity with which the brushes of his engine-driven generator were consumed, although the load was comparatively small and there was no evidence of sparking. All brush-contact surfaces appeared to have been recently sandpapered, but he stated that they had not been touched since their installation about ten days before. It developed that the engine had been shipped from one place and the generator from another and that they had been connected on the ground.

As the commutator showed some eccentricity, a local machinist was engaged to turn the commutator in its own bearings. He had used a diamond-pointed tool, which was all right, but had also used a coarse feed and a comparatively deep cut, thereby converting the commutator surface into a milling cutter, so far as the brushes

were concerned. On being recalled to finish the job, he explained that he had made that kind of surface on purpose, so as to make the brushes "bite better."

In another case, complaint was made that a machine would not generate, but by the time the inspector arrived it was generating all right. The operator stated that, as far as he knew, he had not done anything to help matters, but had let the machine run to "work in the bearings." It seems that he was particular how the machine looked and had been touching up bolt-heads and nuts with gold paint, and while doing this had concluded to give the commutator a coat, with the result that the machine would not pick up until the brush friction had removed the gold paint.

In another case a plain shunt-wound generator and an interpole generator were being operated in parallel. When the attendant wished to withdraw the interpole machine from parallel operation, he found it difficult to reduce its current to a low value. He had observed the practice of oiling commutators occasionally and at such times had noticed the current decrease on the machine. Being in the habit of applying the results of his observations, he adopted the practice of oiling the commutator of the interpole generator whenever he wished to take it out of service. The result was that the commutator absorbed so much oil that it eventually broke down.

Kingsford Double-Flow Pump

Among the line of Kingsford centrifugal pumps is that known as the double-flow type, Fig. 1, which in the illustration is motor driven. It is manufactured by the Kingsford Foundry & Machine Works, Oswego, N. Y.

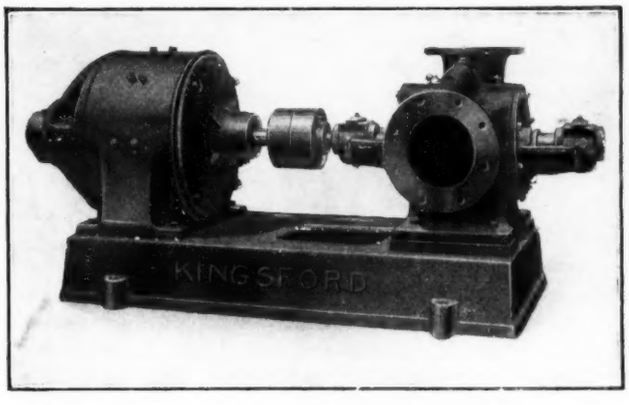


FIG. 1. KINGSFORD DOUBLE-FLOW PUMP

A sectional view of the pump is shown in Fig. 2. In this design the water-ways are liberal, the stuffing-boxes are of ample depth and the span between the oil-ring bearings is small. As the water seals are internal, the leakage is collected in the bearing buckets, and from there piped into a common waste-pipe.

The pump is so designed that with one head removed and the setscrews in the coupling loosened, the shaft and impeller may be removed from the casing without disturbing the suction or the discharge pipe connections. As the joints between the heads and shell are metal to metal, set gaskets are eliminated and alignment is insured. The impellers are made of single castings integral with the balance ring, which under ordinary conditions will wear until the impeller requires renewing. Fig. 3 shows an impeller with staggered veins; this design is used in pumps of large capacity.

Theoretically, the double-suction pump is hydraulically balanced and free from end-thrust, but in practice unequal leakage through packing fissures, inaccuracies in casting or unequal wear, supplemented by lodgment of

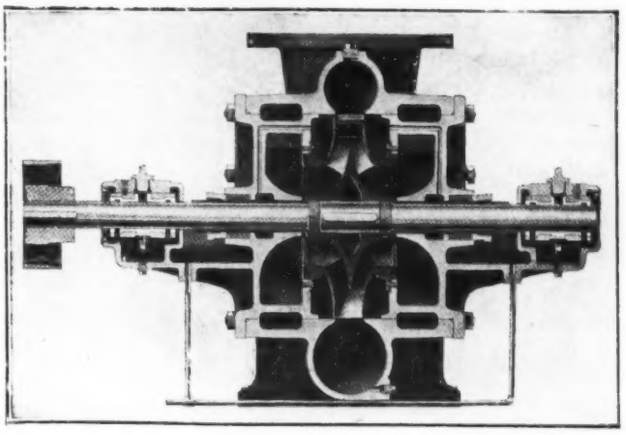


FIG. 2. SECTIONAL VIEW OF THE KINGSFORD DOUBLE-FLOW PUMP

foreign matter, all tend to disturb the theoretical balance, and the result is that end-thrust is present. In this design of pump this difficulty is overcome by automatic water balance, with which it is claimed neither wear nor foreign matter will disturb the equilibrium of the impeller. Therefore, stationary and positive thrust bearings are eliminated.

Leakage from the pressure to the suction side of the impeller is reduced to a minimum by bronze packing rings. They are attached to the heads and in connection with rotating rings on the impeller form part of the automatic water-balance device.

Although the shells or main casings are made split horizontally, when conditions warrant, the pump is generally made with the shell of a single casting with integral sections and discharge openings. The volute surrounding the impeller permits of omitting diffusion veins for low and moderate heads. The design of this pump makes it possible to locate suction and discharge openings at various positions, as for instance a pump with a horizontal or vertical discharge is sometimes found

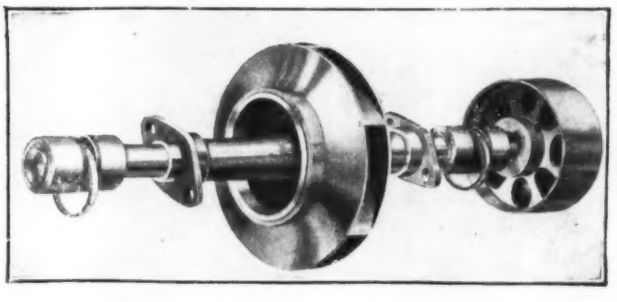


FIG. 3. PUMP SHAFT AND IMPELLER

convenient, and frequently the suction and discharge openings are desired on the same side.

The head and bearing housings, secured to the main casting by studs, come metal to metal, and a water-tight joint is secured by a rubber cord placed in a triangular-shaped space formed in joining the heads and shell. The

head forms a part of the suction chamber and guides the water into the impeller opening.

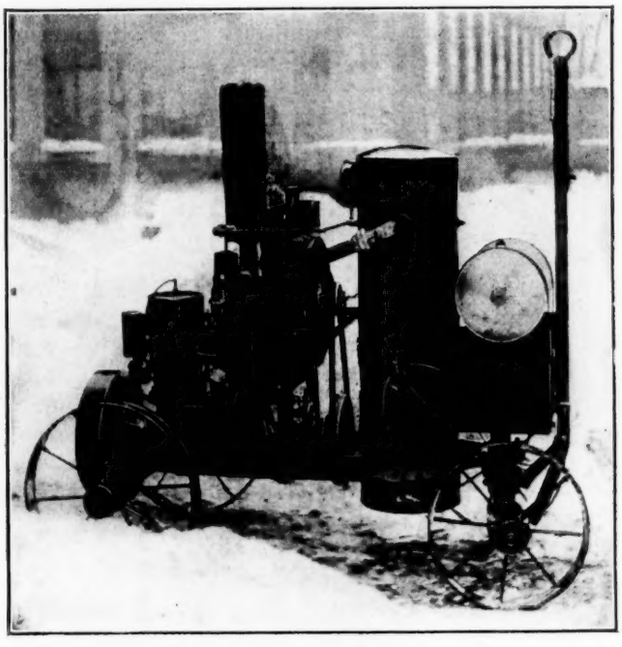
Ordinarily, the pump shaft is of machinery steel, made exceptionally large and stiff to prevent bending and to carry the impeller without vibration. When liquids which affect iron and steel are to be pumped, the shaft is covered by a sleeve of composition metal. This sleeve is provided with threaded ends and fits snugly on the shaft. It is easily removed by a special kind of wrench

In other than belt-driven pumps, a flexible coupling is used between the pumps and prime mover which allows for any slight inaccuracies in alignment. This coupling consists of cast-iron halves, one of which is fitted with steel bolts extending into corresponding holes in the other coupling half, the driving force being transmitted through the medium of rubber cushions mounted on the sleeves.

Imperial Portable Air Compressor

The small portable gasoline-engine-driven air compressor, illustrated herewith, has been developed by the Ingersoll-Rand Co., 11 Broadway, New York City.

The compressor is self-contained and is operated by a simple single-cylinder gasoline engine coupled directly to the compressor, both pistons working on the same



Portable Air Compressor

crankshaft. The engine is of the single-acting, two-cycle type. This standard air compressor has a capacity of 45 cu.ft. per min. at a pressure of 90 lb., and is fitted with an air unloader. The engine speed is controlled by a centrifugal governor.

Cooling is provided for by a gear-driven pump and an automobile-type radiator with large tank capacity, serving both the compressor and the engine. The radiator is assisted by a large fan.

An air receiver tested to 300 lb. water pressure and fitted with a safety valve, pressure gage, the necessary piping, outlets, etc., is hung at one end of the frame and a 15-gal. capacity gasoline tank is supported on a large tool box. The outfit complete weighs 1600 lb., and is designed for hand transportation, but it can be fitted with tongue and singletrees if desired.

Efficiency Test on a Large Alternator

By J. H. McDougal

Some time ago the writer had occasion to test a large alternator to determine its efficiency and segregate the losses. The plant was situated in the mountains, at a very inaccessible point; on which account, together with the fact that the test had to be made on short notice. it was necessary to depart from the common methods of testing.

The machine was a three-phase, 2300-volt, 60-cycle. 5500-kw. alternator direct-connected to two tangential waterwheels and operated in parallel with a number of other plants. The waterwheels were equipped with needle nozzles, the needles being operated by hand and the governing done by deflecting the nozzles. One governor controlled both nozzles.

In order to improve the accuracy of the test, two current transformers were installed of such a size that the losses of the machine, run as a motor, would give full-scale deflection on the indicating wattmeters. The regular two-wattmeter method of measuring three-phase power was used. Both nozzles were disconnected from the governor. It was also deemed advisable to install short-circuiting switches on the current transformers, as in synchronizing practically full load was sometimes thrown on the machine, which it was feared would burn up the small-capacity current transformers. As no regular short-circuiting switches were available, two blades of an old 250-volt quick-break switch were mounted on separate boards and served very well.

In making the test one nozzle, No. 1, was completely closed, and the other, No. 2, was gradually opened until the machine with its field circuit open was brought up to normal speed. After noting the position of the handwheel and the number of turns, the nozzle on this wheel was closed. Nozzle No. 1 was then opened and the machine brought up to speed and synchronized with the system. By adjusting this nozzle the load was brought to zero. Nozzle No. 2 was now opened to the point where it stood in the first part of the test and the amount of power furnished to the system was noted. It will be seen that this power plus that lost in the armature by resistance will equal the power consumed by friction and windage. This is evident, as the water that was used to deliver this power was equal to that used in overcoming friction and windage in bringing the machine up to speed. A very small error would be introduced due to neglecting the load losses, but as this would be but a fraction of one per cent., it may be neglected.

In order to determine the core loss, nozzle No. 1 was closed and No. 2 was used to bring the machine up to speed, and the field current was brought up to the normal full-load running point. The position of nozzle No. 2 was noted and it was then closed. Nozzle No. 1 was now opened and the machine brought up to speed and synchronized. After bringing the load to zero, nozzle No. 2 was opened to its position at the beginning of the core-loss test and the amount of power delivered to the

system noted. This power plus the resistance loss in the armature minus the friction and windage losses gave the core loss.

To check this last reading, all water was taken off the wheels and the generator allowed to run as a motor. This reading checked very closely, although to get satisfactory readings, it was necessary to somewhat change the excitation, which of course changed the core loss to a slight extent.

In the matter of load losses, the recommendations contained in the Standardization Rules of the American Institute of Electrical Engineers were followed. One-third of the short-circuit core loss was, as an approximation and in the absence of more accurate information, assumed as the load loss.

The machine was short-circuited and brought up to speed by nozzle No. 2, and the field current increased until full-load current flowed in the armature windings. The short-circuit was then removed and nozzle No. 2 closed. The machine was synchronized by nozzle No. 1, and No. 2 was opened to the point at which it stood at the beginning of the load-loss test, and the amount of power delivered to the line was noted. The core loss for the excitation used on short-circuit was determined as for the full-load voltage. Therefore, the power shown in the load-loss test plus the armature resistance loss, minus the friction and core loss at the excitation used, divided by three, gave the core loss as nearly as it could be determined.

The armature resistance was measured with an ammeter and a low-reading voltmeter. Thus the armature resistance losses could be calculated. The field resistance was also measured and full-load excitation noted so that the resistance losses in the field could be computed. These completed the list of losses and the efficiency could therefore be computed by dividing the output by the output plus losses. The mechanical losses of the waterwheels were, of course, included in the mechanical losses obtained, but as the guarantee included these, no effort was made to segregate them.

"World's Best" Feed-Water Regulator

The "World's Best" automatic feed-water regulator, manufactured by the McDonough Automatic Regulator Co., Detroit, Mich., is of the thermostatically controlled type. The main purpose of its design is not only to secure a continuous feed, but a positive automatic control of a continuous feed to vary with the boiler load and to maintain a water level within limits best suited for constant maximum boiler capacity, efficiency and uniformity of operating conditions.

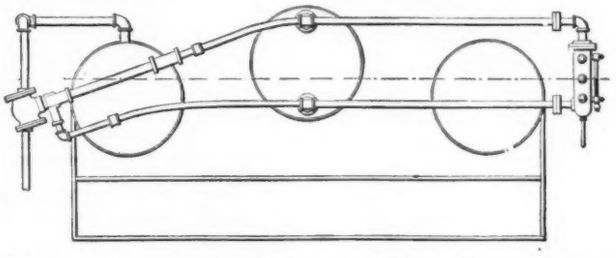


FIG. 1. POSITION OF REGULATOR WHEN CONNECTED TO A BOILER

This regulator, Fig. 2, maintains a continuous feed proportional to the evaporation and for light and uniformly varying loads a constant water level. For sudden increase in load and the resulting rapid drop in the water level, the regulator valve does not open suddenly to admit a large quantity of water into the boiler, but there is a time element in the expansion of the tubes operating the valve which uniformly increases the feed, permitting the immediate furnace heat to be used for evaporating and not for heating cold feed water.

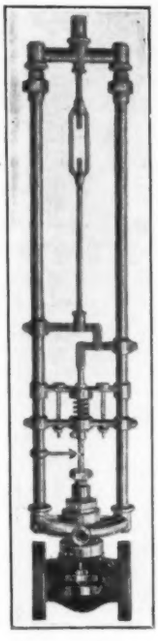


FIG. 2. REGULATOR

This regulator consists of a special feed valve, two headers and two expansion tubes connected in parallel through a rigid linkage to the feed-valve stem. The use of two tubes doubles the power of expansion and contraction, and the levers transmit the motion to the feed valve in a ratio of 5 to 1. A turnbuckle and pointer indicator permit of accurate adjustment of the valve, and the pointer indicator shows the position of the valve while the regulator is in operation.

The regulator is installed in an inclined position, Fig. 1, wholly supported by the feed piping with the connections made to the water column, as shown. In operation, the lower ends of the tubes are filled with water and the upper with steam. As the water falls or rises in the boiler, it correspondingly falls or rises in the regulator tubes, presenting a greater or lesser area of the tube surface to the steam, causing them to expand or contract accordingly. The inclined position of the regulator gives the greatest variation in exposed tube surface for a given variation in water level and the greatest sensitiveness to variations in load.

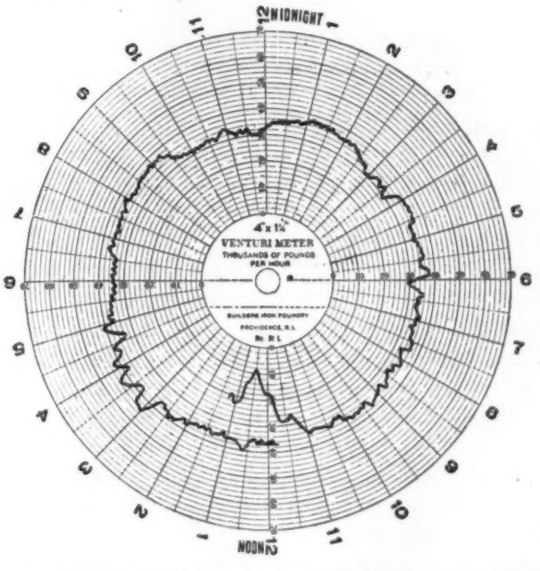


FIG. 3. CHART SHOWING FEEDING CHARACTERISTIC OF THE REGULATOR

The chart, Fig. 3, taken from two boilers in regular service, each equipped with this regulator, shows the uniform and constant feeding characteristic of the device.

Pipes for Steam Engines

By Frederick W. Salmon

SYNOPSIS—In the literature on the proper size of steam and exhaust pipes for steam engines there is little in practical shape for ready use; therefore, data of sizes of a large number of successful plants have been plotted and tables given of values obtained by plotting smooth curves representing fair averages of good practice.

There are two methods of determining pipe sizes—one is by a long and elaborate computation of pipe friction, with the use of coefficients based on a limited number of experiments; the other is what some people would call a rule-of-thumb, in which the pipe size is determined as a fraction of the cylinder diameter. The first of these is commonly based on a steam velocity in feet per minute or per second.

For the modern steam plant in a factory or the municipal plant of a small city, designed according to conventional practice and having a fair grade of reciprocating engines set close to the boilers, it is much more convenient to calculate pipe sizes from the gross pounds of steam per hour required by the engine at the best rated load and make use of a formula based on the most suitable pipe size as established by several decades of good commercial practice.

The old rule-of-thumb would answer but for the fact that during the past few years some of the engine builders have increased the rated speeds of their engines—and therefore the rated horsepower and steam consumption—without apparently increasing the pipe sizes, and in some cases wire drawing results; whereas, if these simple formulas were used for the pounds per hour and the pipe sizes chosen accordingly, the wire drawing would not be higher than that heretofore established as good practice.

The curves and constants given in the chart are from the mean curves found by plotting the results of data obtained of sizes of engine pipes used in a large number of successful power plants. The maximum and minimum curves were quite irregular, but they appeared to vary up to about 10 per cent. of the mean values.

As illustrating the use of the table, take the case of a 14x36-in. noncondensing Corliss engine under 100-lb. steam pressure by gage, and running 100 r.p.m., which is rated by the builders at about 135 i.hp. at ¼ cutoff (the rating of different builders varies somewhat), and assume such an engine at that load to take 26 lb. of steam per hour, which is about what many engine builders guarantee in their contracts for such a size under these conditions There is then 135 i.hp. × 26 lb., or about 3500 lb. of steam per hour, and looking on the chart the nearest sizes are found to be 4-in. steam pipe and 5-in. exhaust, which sizes are as small as one should like to make them for ordinary conditions of plant arrangement.

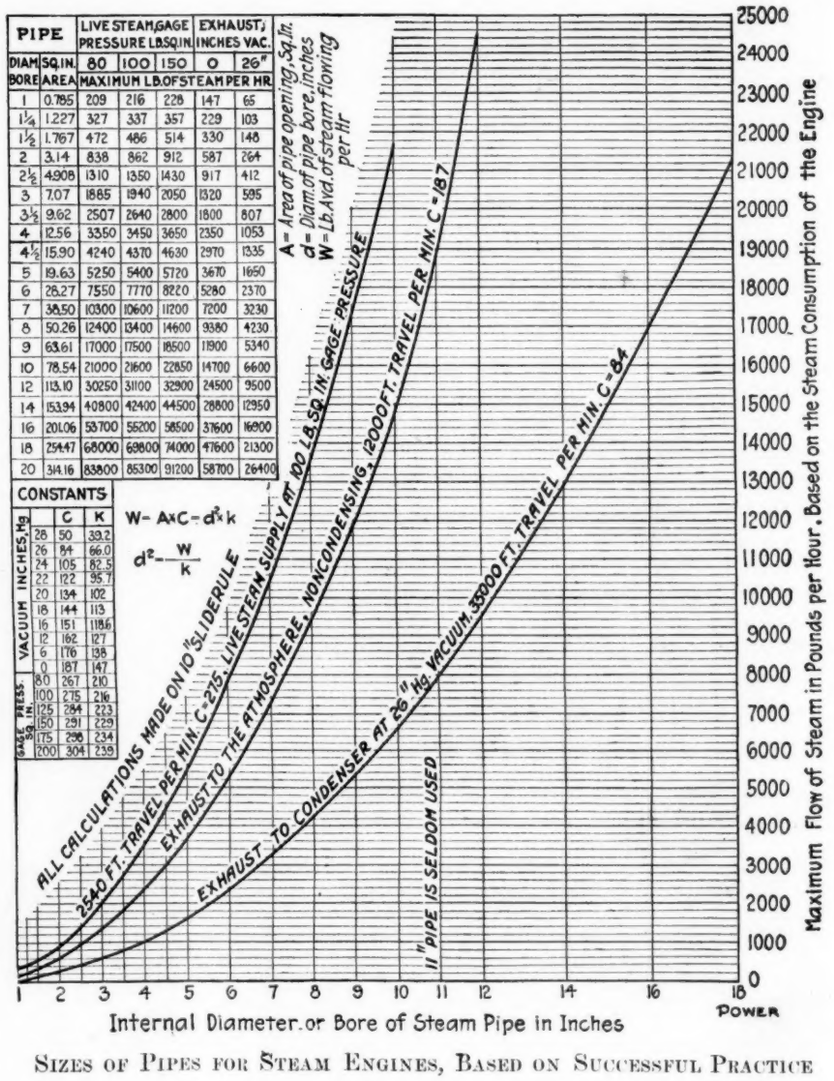
In special cases of very large plants or long steam mains, the drop in pressure from pipe friction should be calculated. Perhaps that method of choosing pipe sizes should be followed, but the table will be found useful for a large percentage of the cases arising in practice.

PIPE		LIVE STEAM, GAGE PRESSURE LB. SQ. IN.			EXHAUST, INCHES VAC.	
DIAM. BORE	SQ. IN. AREA	80	100	150	0	26"
		MAXIMUM LB. OF STEAM PER HR.				
1	0.785	209	216	228	147	65
1¼	1.227	327	337	357	229	103
1½	1.767	472	486	514	330	148
2	3.14	838	862	912	587	264
2½	4.908	1310	1350	1430	917	412
3	7.07	1885	1940	2050	1320	595
3½	9.62	2507	2640	2800	1800	807
4	12.56	3350	3450	3650	2350	1053
4½	15.90	4240	4370	4630	2970	1335
5	19.63	5250	5400	5720	3670	1650
6	28.27	7550	7770	8220	5280	2370
7	38.50	10300	10600	11200	7200	3230
8	50.26	12400	13400	14600	9380	4230
9	63.61	17000	17500	18500	11900	5340
10	78.54	21000	21600	22850	14700	6600
12	113.10	30250	31100	32900	24500	9500
14	153.94	40800	42400	44500	28800	12950
16	201.06	53700	55200	58500	37600	16900
18	254.47	68000	69800	74000	47600	21300
20	314.16	83800	85300	91200	58700	26400

CONSTANTS			
VACUUM INCHES, Hg		C	K
	28	50	39.2
	26	84	66.0
	24	105	82.5
	22	122	95.7
	20	134	102
	18	144	113
	16	151	1186
	12	162	127
	6	176	138
	0	187	147
GAGE PRESS. SQ. IN.	80	267	210
	100	275	216
	125	284	223
	150	291	229
	175	298	234
	200	304	239

$W = A \times C = d^2 \times k$

$d^2 = \frac{W}{k}$


A = Area of pipe opening, Sq. In.
d = Diam. of pipe bore, inches
W = Lb. Avd. of steam flowing per Hr.
ALL CALCULATIONS MADE ON 10" SLIDE RULE
2540 FT. TRAVEL PER MIN. C = 275 - LIVE STEAM SUPPLY AT 100 LB. SQ. IN. GAGE PRESSURE
EXHAUST TO THE ATMOSPHERE, NONCONDENSING, 1200 FT. TRAVEL PER MIN. C = 187
EXHAUST TO CONDENSER AT 26" Hg. VACUUM, 33000 FT. TRAVEL PER MIN. C = 84
11" PIPE IS SELDOM USED
Internal Diameter or Bore of Steam Pipe in Inches
Maximum Flow of Steam in Pounds per Hour, Based on the Steam Consumption of the Engine
POWER

Sizes of Pipes for Steam Engines, Based on Successful Practice

Ignorance—A visitor who could tell about volts and amperes was walking through a 110,000-volt substation pointing at high-tension oil switch leads with an umbrella that had a steel stick in it. The foreman put him out before the current got a crack at him.

Laborer Cooling a Hot Box over a 650-volt third-rail with a metal pail of water that had been salted to prevent freezing: They succeeded in bringing him to.

Capacity and Power of Hydraulic Pumps

By R. A. Lachmann

The accompanying tables provide a ready means of ascertaining the power and capacity of a plunger pump. Although computed for single-acting pumps with a slip of 5 per cent., and working against a pressure of 1000 lb. per sq.in., they may, by a few simple calculations, be made to apply to any direct-acting pump. A couple of examples will make this clear.

TABLE 1—CAPACITY AND POWER OF SMALL SINGLE-ACTING HYDRAULIC PUMPS

No. of Plungers	Diameter of Plungers, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
1	½	1½	28	0.12	100	25	1000	0.1
	⅝		44	0.19				0.15
	¾		63	0.27				0.2
2	½		56	0.24				0.2
	⅝		88	0.38				0.3
	¾		126	0.54				0.4
3	½		84	0.36				0.3
	⅝		132	0.57				0.45
	¾		189	0.81				0.6
1	½	2	37	0.16	100	33	1000	0.13
	⅝		59	0.25				0.2
	¾		84	0.36				0.27
2	½		75	0.32				0.27
	⅝		117	0.51				0.4
	¾		168	0.72				0.53
3	½		112	0.48				0.4
	⅝		176	0.76				0.6
	¾		252	1.08				0.8
1	½	2½	47	0.2	100	42	1000	0.16
	⅝		73	0.32				0.25
	¾		105	0.45				0.33
2	½		93	0.4				0.33
	⅝		147	0.63				0.5
	¾		210	0.9				0.66
3	½		140	0.6				0.5
	⅝		220	0.95				0.75
	¾		315	1.35				1.00
1	½	3	56	0.24	100	50	1000	0.2
	⅝		88	0.38				0.3
	¾		126	0.54				0.4
2	½		112	0.48				0.4
	⅝		176	0.76				0.6
	¾		252	1.08				0.8
3	½		168	0.72				0.6
	⅝		264	1.14				0.9
	¾		378	1.62				1.2

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

TABLE 2—CAPACITY AND POWER OF LARGE SINGLE-ACTING HYDRAULIC PUMPS, SINGLE PLUNGER—¾-IN. TO 1¾-IN. DIAMETER

Diameter of Plunger, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
¾	4	168	0.72	100	66	1000	0.53
⅞		229	1.00				0.72
1		298	1.29				0.94
1⅛		378	1.64				1.20
1¼		466	2.02				1.48
1⅜		564	2.44				1.78
1½		672	2.91				2.12
1⅝		788	3.41				2.49
1¾		915	3.96				2.90
¾	5	210	0.90	100	84	1000	0.66
⅞		286	1.25				0.90
1		373	1.61				1.18
1⅛		473	2.05				1.50
1¼		583	2.53				1.85
1⅜		705	3.05				2.23
1½		840	3.64				2.65
1⅝		985	4.26				3.11
1¾		1144	4.95				3.62
¾	6	252	1.08	100	100	1000	0.80
⅞		344	1.50				1.08
1		447	1.94				1.41
1⅛		567	2.46				1.80
1¼		700	3.03				2.22
1⅜		846	3.66				2.67
1½		1008	4.37				3.18
1⅝		1182	5.12				3.74
1¾		1373	5.94				4.35

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

Assume a two-plunger pump with ¾-in. plungers, a 2½-in. stroke (the movement of the plunger in one direction) and a speed of 100 r.p.m. when working against a pressure of 1000 lb. per sq.in. Under these conditions the capacity and necessary horsepower can be read directly from Table 1.

First, look for 2½ in. under the heading "stroke;" then the number 2 in the column headed "number of plungers," and opposite this for the plunger diameter of ¾ in. Following this line to the right, there will be found the desired information under the respective columns; that is, the capacity in cubic inches per minute will be 210, the capacity in gallons per minute will be 0.9, and the horsepower required to drive the pump will be 0.66. A 1-hp. motor would probably be selected.

TABLE 3—CAPACITY AND POWER OF LARGE SINGLE-ACTING HYDRAULIC PUMPS, SINGLE PLUNGER—1⅞-IN. TO 4½-IN. DIAMETER

Diameter of Plunger, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
1⅞	4	1049	4.54	100	66	1000	3.31
2		1194	5.17				3.77
2¼		1511	6.54				4.77
2½		1865	8.07				5.89
2¾		2257	9.77				7.12
3		2686	11.63				8.48
3½		3656	15.83				11.54
4		4775	20.67				15.07
4½		6044	26.16				19 08
1⅞	5	1311	5.68	100	84	1000	4.14
2		1493	6.46				4.71
2¼		1889	8.18				5.96
2½		2331	10.09				7.36
2¾		2821	12.21				8.90
3		3358	14.54				10.60
3½		4570	19.79				14.43
4		5969	25.84				18.84
4½		7555	32.70				23.85
1⅞	6	1574	6.81	100	100	1000	4.97
2		1791	7.76				5.66
2¼		2267	9.81				7.16
2½		2798	12.11				8.84
2¾		3386	14.66				10.68
3		4029	17.45				12.72
3½		5484	23.75				17.31
4		7163	31.01				22.61
4½		9066	39.24				28 62

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

Now assume the following conditions: Stroke, 2½ in.; diameter of plungers, ¾ in.; number of plungers, 4; speed, 150 r.p.m.; pressure, 1700 lb. per sq.in. Find the capacity and the horsepower required.

As the quantities and sizes involved are directly proportional to those in the table, first double the quantities given for two ¾-in. plungers; this gives the first multiplier, namely 2. Then since 150 r.p.m. is 1.5 times 100 r.p.m., shown in the table, the second multiplier will be 1.5. The third multiplier is 1.7, since 1700 lb. is 1.7 times 1000 lb. The product of these three multipliers is:

$$2 \times 1.5 \times 1.7 = 5.1$$

which is the common multiplier. Then the capacity is

$$5.1 \times 210\ cu.in. = 1071\ cu.in.\ per\ min.$$

$$5.1 \times 0.9\ gal. = 4.59\ gal.\ per.\ min.$$

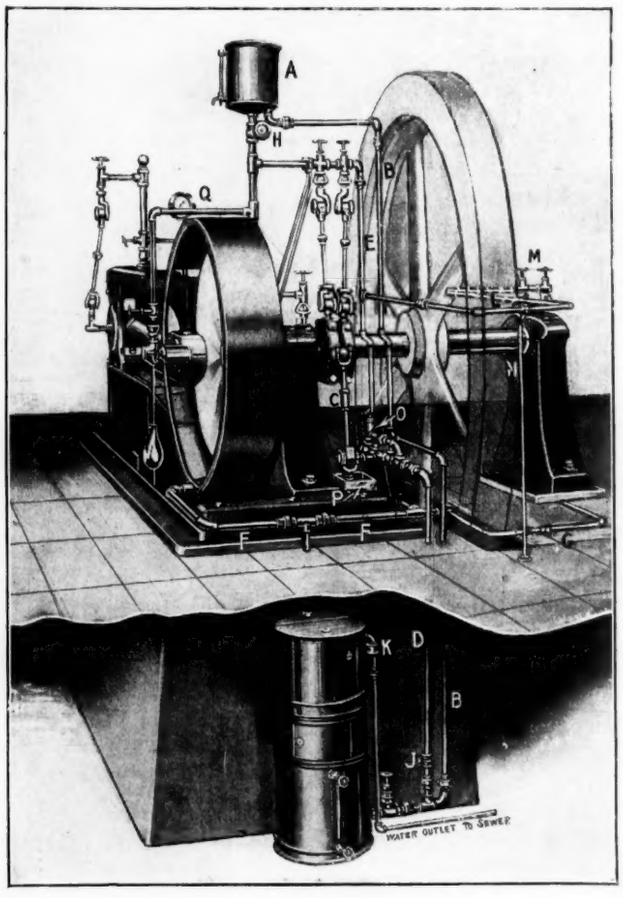
and

$$5.1 \times 0.66\ hp. = 3.366\ hp.$$

or about 3½ hp. would be required.

Nugent Pressure Return Oiling System

From time to time in these columns the various Nugent lubricating devices, such as the pendulum crankpin oiler, the antipacked telescopic oiler for crossheads and eccentrics and the illuminated oil filter with the automatic water separator, have been described. For about a year, however, the company has been combining these various devices into a complete pressure system for individual units, such as is shown in the accompanying illustration.



NUGENT OILING SYSTEM

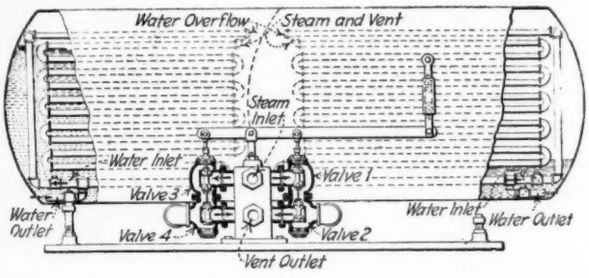
A simple plunger pump actuated by the engine eccentric draws the oil through the pipe *D* from the storage space of the filter. The oil is forced to the system on the engine and to the reservoir *A*, which is provided with a gage glass and an overflow leading from the top of the tank. The oil flows back to the filter through the pipe *B*. By manipulating the valve *H* any pressure up to 25 lb. can be maintained on the system. A check valve *J* prevents oil returning to the filter through the suction. Open-sight feeds supply the oil to the various points of service, and drains *F*, *F* and *G* from the crankpit, eccentric pan and outboard pillow block return the oil to the water separator and oil filter shown under the floor. If any of the openings in the sight-feeds should become clogged, it is an easy matter to force up the pressure to the limit previously given and blow out the obstacle. The safety valve *O*, set at 25 lb., protects the system.

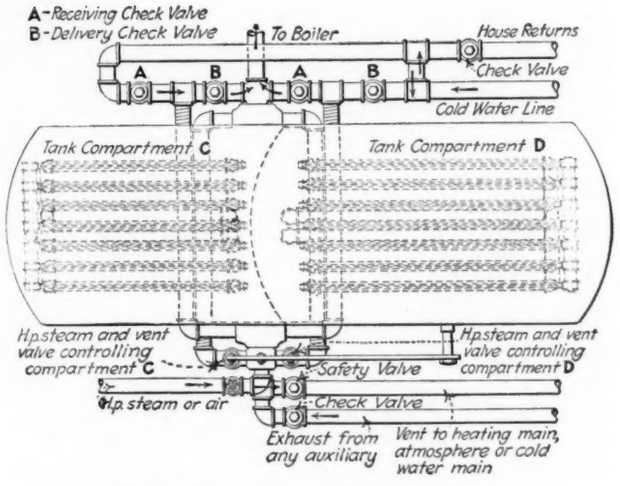
Pipes *L* and *M* convey the oil to the outboard bearing, *N* is a support for pipe *L*, *K* is a sight-feed in the water-outlet pipe leading to the sewer, *Q* is a gage to show the pressure on the system, and *P* is a drip pan for the oil pump. The system is thus complete in itself and is actuated by the unit it serves. If any trouble should develop it is localized to the one unit. Additional information may be obtained from W. W. Nugent & Co., Chicago, Ill.

Farnsworth Tilting Traps

A combined feed-water trap, heater and weigher is being marketed by the F. C. Farnsworth Co., Bush Terminal, Brooklyn, N. Y. The illustration shows a section of this tilting type of apparatus.

The tank has two compartments which fill and empty alternately. Instead of trunnions, flexible copper hose is used. Water is carried to the top of each compartment and distributed over the copper heating coil through a perforated pipe. First, the coil is heated by exhaust steam fed in through the vent valve. When the compartment fills with water its weight tilts the tank, interchanging the valve, venting the opposite side and simultaneously admitting steam at boiler pressure in the coil and out onto the surface of the water to force the latter into the boiler.





THE FARNSWORTH TILTING TRAP

The trap may be furnished with or without the heater. A counter may be made to register the number of oscillations and the weight of water delivered calculated from the reading.

Traps acting on the same principle, but with modification of the inlets, outlets and partitions, are adapted to services such as those of a blowoff or condensate weighing tank and trap, and of sewage or water lifts using steam or compressed air.

Special Reconstruction Jobs*

By Osborn Monnett†

SYNOPSIS—Limited headroom and floor space call for unusual designs of setting not recommended for standard practice. Some interesting cases are presented.

Installing new boilers in old office buildings offers one of the most difficult problems the designer will encounter if smokelessness is one of the prime considerations. Fig. 1 shows how it was done in a plant requiring additional boiler capacity with limited floor space and headroom in which to install it. It was necessary to provide 100 boiler-hp. in a floor space of 7 ft. 5 in. by 8 ft. 5 in. and a headroom of 10 ft. and to find room for a smokeless setting. The solution was a Worthington boiler of special design in which the rear mud drum extended some 18 in. below the normal position and connected with the front mud drum by 2½-in. tubes, spaced 4 in. on centers. It gave 48 in. of free space between the bottom of the front mud drum and the floor line and provided opportunity for a tile roof on the tubes connecting the mud drums. Strong ignition for a Moore stoker installed directly under the boiler was thus obtained. This unit has met every requirement of floor space and headroom and is running smokelessly on loads up to 40 per cent. above rating. The same combination in almost any capacity can be supplied by simply adding to the width of the setting without increasing the headroom or floor space in a lengthwise direction.

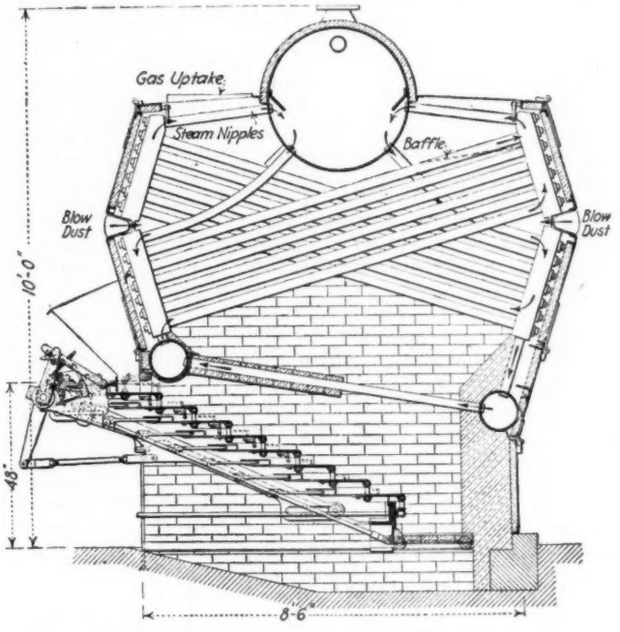


Fig. 1. Worthington Boiler, 100 Hp., and Moore Stoker

Fig. 2 is another application of the Worthington boiler to limited floor space. The floor space occupied by the boiler is 10 ft. 2 in. wide by 11 ft. long, while the stoker adds 3 ft. 3 in. to the length. The headroom to the steam nozzle of the boiler is 16 ft. This unit is of 300 boiler-hp. capacity. The ignition arch is 6 ft. long, with a low-pressure water-back furnishing a permanent support for the built-up bridge-wall. Between the two, good throat action is obtained, insuring complete combustion and good economy. The arch is supported by another low-pressure water-back and provision is made for ventilation over the arch to insure satisfactory life.

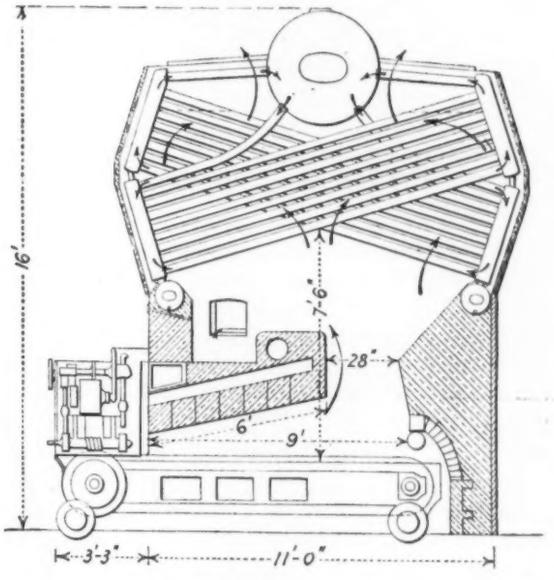


Fig. 2. A 300-Hp. Worthington Boiler and Chain Grate on Limited Floor Space

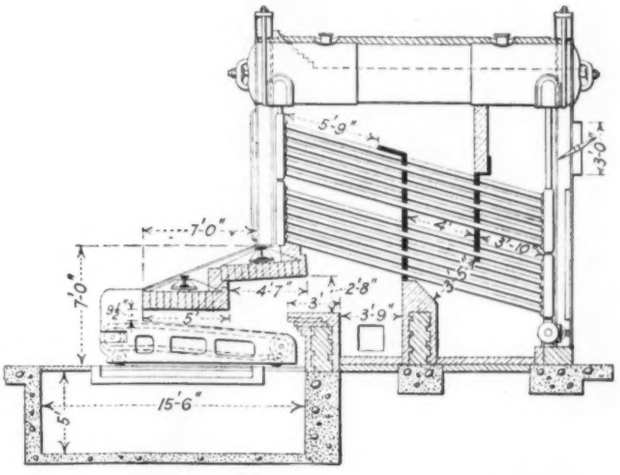


Fig. 3. A 390-Hp. B. & W. Boiler and Laclede-Christy Chain Grate; 7-Ft. Headroom and 7-Ft. Extension

The horizontal water-tube boiler, vertically baffled, equipped with a chain grate, short ignition arch and short flame travel, is frequently encountered. This type of setting is a constant smoker. It is true that the smoke may not at all times be dense enough to be a violation, but there is hardly a moment in the twenty-four hours during which No. 1 or No. 2 smoke on the Ringelmann chart

*Copyright, 1915, by Osborn Monnett.
†Smoke Inspector, City of Chicago.

is not emitted. This is due to the volatile matter being chilled by the nest of tubes before combustion can be completed. Frequently the setting is erected with only 6-ft. space from the floor line to the front header, so that considerable remodeling is necessary before good results may be expected.

The best method of cleaning up these settings is by raising the boiler or lowering the floor, and putting in horizontal baffles. A good illustration of this is given in Figs. 1 and 3 on pages 532-3 of the Oct. 13 issue. Sometimes the boiler is set high enough so that only the combustion-chamber floor need be lowered when the horizontal baffle is put in. In any case, liberal space must be provided in the combustion chamber to avoid "bottling" the heat, and therefore burning up the arches and tiling. Occasionally, when floor space is to be had in front of the boiler, it has been possible to pull out the stoker and get enough flame travel to clean up the setting.

A case of this kind, Fig. 3, consists of a B. & W. boiler with a Laclede-Christy chain grate in 7 ft. of headroom, built out 7 ft. from the gate to the flue caps and having a 5-ft. flat ignition arch, followed with a 4-ft. 7-in. secondary arch. This unit operates smokelessly and may be considered satisfactory up to rated capacity. Of course, such a setting cannot be considered good for capacities above rating, but it can be taken as a reconstruction possibility where conditions permit.

Results of Changes in Boiler Furnace

By Morgan B. Smith*

SYNOPSIS—A specific instance where the efficiency of two 500-hp. Stirling boilers, each fitted with two Roney stokers, was greatly increased by enlarging the combustion chamber or furnace.

At the instance of E. J. Burdick, superintendent of power, Detroit United Railway Co., the writer in conjunction with F. L. Fisher, Chief Engineer of the Rochester, Mich., power station, carried out at the company's laboratory an extensive investigation of the rate at which combustion progresses in Stirling boilers, each having two Roney stokers.

This investigation showed that completion of combustion is delayed at a point too far back in the gas travel when such boilers are fitted with Roney stokers and restricted combustion chambers, as is the case when each stoker is housed in a separate furnace and long combustion arches are used. Combustion was never complete short of the bottom of the second pass and at times not even half-way up the last or third pass. This was manifestly bad practice, resulting in the production of dense smoke and relatively low efficiency.

It is obvious that the cure for this condition lay in so designing the furnaces as to assure quicker completion of combustion before the gases turned downward into the second pass. It was believed that less restriction of the gases would give this result and that less smoke would be produced; higher efficiency ought also to be attained. With a less restricted combustion chamber the volatile constituents in the fuel would be distilled less rapidly, owing to lower furnace temperatures, and less smoke would result as these products would have time for complete ignition before impinging on the relatively cool tube surfaces.

We determined to gradually cut away the long arches and note the results after prolonged operation. In this we were disappointed, for the division wall in one of these boiler furnaces, already weakened, gave way and let both arches down. There was nothing to do but to clear away the mass of firebrick and get the boiler back on the line as soon as possible. Advantage was taken of this new state of affairs by making a thorough study of the boiler operation without arches, comparing this to the old operation with the arched furnaces.

The division wall was trimmed down to follow the line of the grates (inclined) and made 6 in. higher. We now had one large high furnace with no division wall to break up the flow of the furnace gases. We found that we must protect the front wall of the setting, so we extended the coking arch 10 in. inside this wall, battering it back against the wall, at the same time protecting the structural-steel frame at the front of the boiler. This gave 22 in. of coking arch, the only arch in the furnace. We also increased the height of the first or front baffle one foot, giving 13 sq.ft. more baffling surface, a longer gas-travel, and a reduction of the breeching temperature.

These boilers have been in operation six months and as a result of the efficiency attained we are similarly modifying all of these furnaces. It is expected to have a Stirling boiler fitted with Murphy stokers in satisfactory operation without any arch in a short time.

In all our power stations we reduce the results to a basis of kilowatt-hours obtained per million heat units supplied to the furnaces. The data given below show the results obtained since taking out the long arches as against results with long arches—i.e., large, unrestricted combustion spaces against small, confined spaces.

COMPARATIVE OPERATION

	Restricted Spaces	Unrestricted Spaces
Combustion arch, in.	72	None
Coking arch, in.	12	22
Division wall, in.	72	72
Height above grate, in.	Full	6
Kw. hr. per million B.t.u.	17.50	23.52
Breeching temperature, deg. F.	560	558
CO_2 average at the breeching, per cent	9.00	12.50
Smoke by Ringelmann charts, average	No. 3.	Average less than No. 1
Temperatures in boiler:		
Over fires, deg. F.	2462	2092
Bottom of front tubes, deg. F.	2370	2000
Top of first pass, deg. F.	1000	1175
Bottom of second pass, deg. F.	690	710
Top of third pass, deg. F.	570	558
Ashes produced:		
Ash-in-ashes, per cent	69.34	79.74
Combustible in ashes, per cent	30.66 (by diff.)	70.26
Draft losses—taking draft at breeching side of back damper as 100 per cent.:		
Under grates, per cent	8.25	8.25
Over grates, per cent	34.50	34.50
Top of first pass, per cent	40.00	35.50
Bottom of second pass, per cent	48.50	50.00
Top of third pass, per cent	67.50	69.50
Boiler-side of back damper, per cent	92.50	93.50
Breeching-side of back damper, per cent	100.00	100.00

All draft readings were taken with the inclined tube type of draft gage, reading directly to 1/100-in. water pressure.

The electrical unit operated during this period consisted of a 2000-kw. alternating-current generator driven

*Chief chemist and combustion engineer, Detroit United Railway Co.

by a turbine fitted with a jet-type condenser. The load varies from 1250 to 2500 kw. and is difficult to handle economically because of frequent peak-load conditions of short duration.

The coal figures in the table include the daily three and one-half to four hours of banking during the night. All coal received is sampled and tested for heat value in a standard Atwater bomb calorimeter and the wattmeters are checked frequently with master meters.

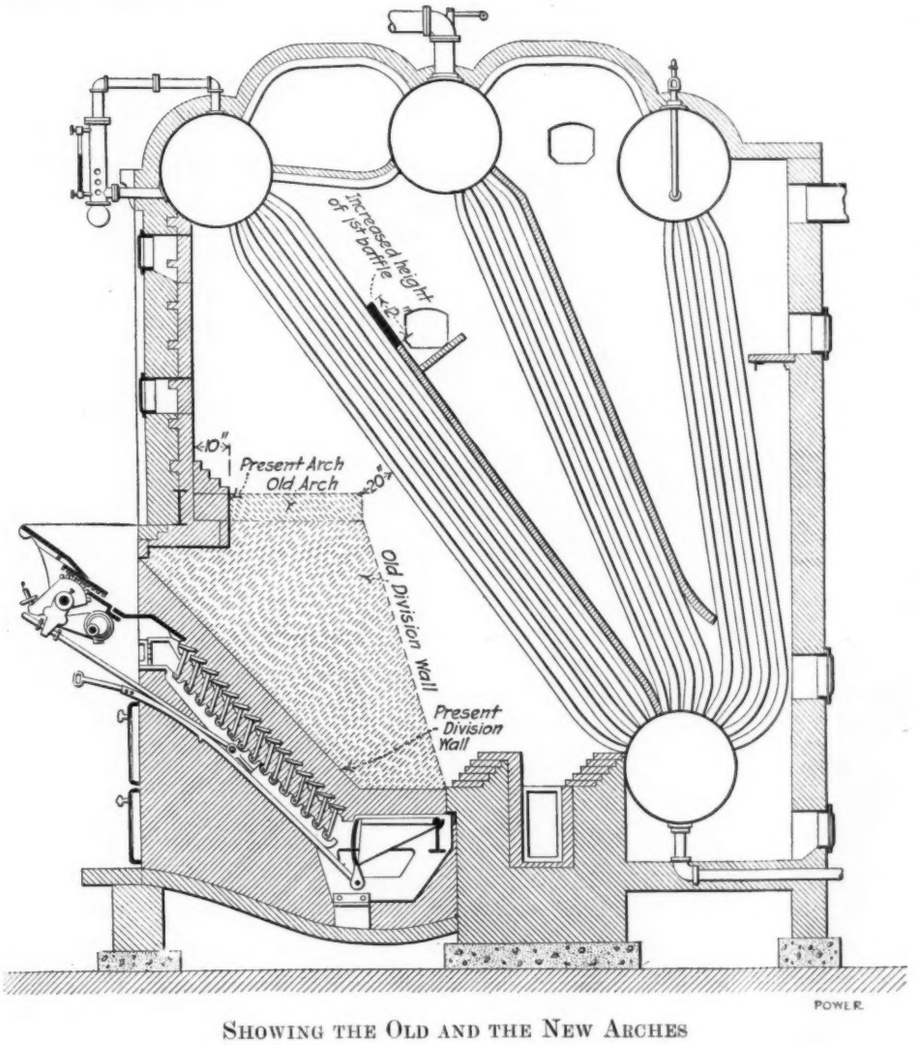
COAL FIRED (Average)

All coal is dried at 105 deg. C. for one hour before testing. Coal received averages 10 per cent. moisture at the stations.

B.t.u. per lb	13.962
Volatile matter, per cent	36.77
Fixed carbon, per cent	54.33
Ash, per cent	8.90
Sulphur (Eschka), per cent	2.18

CONDENSER DATA (Average)

Condenser intake, temperature, deg. F	53.5
Condenser discharge, temperature, deg. F	73.3
Average vacuum produced, mercury, in	28.5



SHOWING THE OLD AND THE NEW ARCHES

The turbine water-rate is approximately 14 lb. under operating conditions. To handle the load requires that the two boilers shall run at an average of from 160 to 175 per cent. of rating.

Points noted in the operation of these boilers with modified furnaces are:

1. Virtually no smoke is produced, a mere haze being visible most of the time. No soot of a black, oily nature is made, the accumulation on the tubes and around the clean-out doors being more like fire-clay than soot.

2. More even heat absorption in the three banks of tubes is attained. The front bank is greatly relieved of the high heating effect of the gases as they travel over the old arch. Both the second and third banks of tubes do more work. The front bank will show longer life than with the arched construction.

3. Deterioration of the grates is less, due to lower furnace temperatures.

4. Better quality flue gases are obtained, no CO being found until the CO_2 reaches 16 per cent. The average CO_2 figures given are somewhat lower than the true maximum because of the loss of from 1 to 1.5 per cent CO_2 in air of infiltration through the boiler settings.

5. Less coal and ashes are handled, also less soot.

6. Cost of firebrick arches is eliminated.

7. Peak loads are carried more easily because we can burn more coal in a given time than before.

8. The water level in the boilers does not surge as before because the front bank of tubes is heated almost uniformly throughout its length.

9. There seems to be no need of a fourth pass in the gas travel, although this might improve the efficiency if it did not unduly cut down the draft available (natural draft; chimney 200x10 ft.).

10. Combustion is now completed before the gases turn downward into the second pass, except when the boiler is being pushed above 175 per cent. of rating, at which times combustion is carried further into the passes, being completed at the middle of the second pass. As these boilers seldom exceed 160 per cent. of rating, the object of these experiments may be said to have been accomplished. The slower rate of distillation of the volatile matter in the fuel together with better mixing conditions (volatile matter with oxygen) is the secret of the elimination of smoke.

We believe that these boilers should be set 4 ft. higher than at present, in which case even better results should be attained with the given fuel. Choice of fuel has much to do with furnace and boiler-setting design; too little attention is given to such items. With higher boiler settings the brickwork is increased and the danger of leaky settings is augmented, but with settings properly incased this should not cause alarm.

Tension on Brushes should be set by the aid of a small spring balance, so that all the brushes will bear with an equal pressure. This refers especially to high-speed machines; the pressure will vary from about 8 to 10 oz. per sq.in. of brush surface in slow-speed machines up to 1¼ lb. in the high-speed types.

Concrete Filling for Engine Beds and Machine Frames

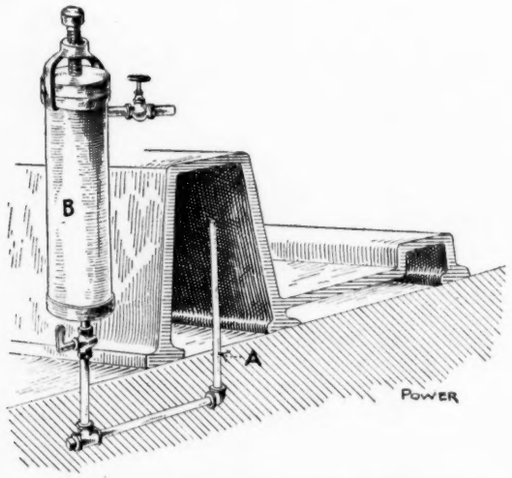
By F. W. Salmon

Should the bed of a large engine or generator be filled solid with concrete? A concrete filling will tend to absorb the vibration, reduce the noise from pounding and give the bedplate a larger and better bearing upon the foundation.

I have had bedplates filled with concrete, and it has always proved advantageous. Some of these have been filled before erection by turning the bedplate bottom-side up and filling the space with a mixture of one part of portland cement to three or four of clean sharp sand, and allowing it to set.

If the engine or machine is already erected and loose on the foundation, or acts like a piano sounding-board, it can be easily filled in the manner shown in the illustration. A small air vent, ¼-in. pipe size, is tapped at the highest point of each compartment or space. The old grouting is channeled out and pipe *A* put in and well grouted in place with equal parts of portland cement and sand.

The charging cylinder *B* can then be screwed on and connected to a supply of compressed air. Grout is put in, the cylinder quickly closed, and a light pressure of air—say 10 to 30 lb.—is turned on to drive the grout into the space to be filled. Do not allow any grout to stand in the pipes or the cylinder, as it will set. Blow the grout out clean each time as soon after filling as possible and at night take down cylinder *B* and wash it clean with water.



Means of Filling Hollow Bedplates

In many cases this work is done gradually, a little put in one day, more the next, and so on. The pipe *A* should extend nearly to the top of the inside of the frame in every case, so that the grouting cannot run back into it, while refilling the cylinder *B*.

In a few cases, I have had a little air pressure kept on the top of the concrete during the time it was setting, thus insuring the concrete being in good contact with the inside of the bedplate at all points, but care must be exercised to avoid springing the bedplate.

Sand, of course, may be used after a small layer of concrete has been introduced and has hardened, but solid concrete is more desirable in every case as it reduces the vibration and noise much better than sand and gives the bed greater support.

My experience is that filling an engine or heavy machine bedplate with concrete costs but little and is a good thing to do.

Standard Pipe Threads

The illustration under the above heading in the issue of Nov. 3, p. 646, is not correct in that threads *F* should

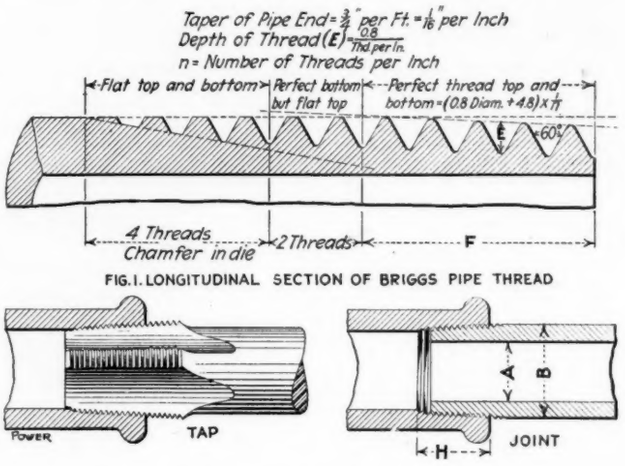

Taper of Pipe End = 3/4" per Ft. = 1/16" per Inch
Depth of Thread (E) = 0.8 / Thd. per In.
n = Number of Threads per Inch
Flat top and bottom
Perfect bottom but flat top
Perfect thread top and bottom = (0.8 Diam. + 4.8) x 1/n
60°
E
4 Threads Chamfer in die
2 Threads
F

FIG. 1. LONGITUDINAL SECTION OF BRIGGS PIPE THREAD

Briggs' Standard Pipe Thread

be perfect at top and bottom to agree with the text, and the decimal point is missing in one formula. The new illustration herewith is corrected in these particulars.

The Sediment in a Boiler will accumulate in the portion of the bottom near to the region of the bridge-wall in the furnace; and if you have no such thing as a bridge-wall it will accumulate where the fire is hottest. This is a result of heat movements that send the hot water upward from highly heated spots while the cooler water surrounding sweeps in below, carrying with it sediment that builds a little mound, if there is some one spot that is materially hotter than the rest of the surface exposed to the fire.

In a Refrigerating Plant, if one wishes to obtain the best results, the machinery should be run regularly and evenly; otherwise things will go wrong. When excessive quantities of liquid come back to the compressor, the compressor piston-rod stuffing-box will start to leak. It is bad practice to tighten up on the stuffing-box glands because the rod contracts when cold, but when the frost disappears it becomes hot and expands again so that the leak will disappear; otherwise the packing will burn when the rod expands. When the frost comes back to the machine on account of low steam pressure, which causes the machine to slow down, the best thing to do is to shut the main liquid valve for a while or stop the machine, after having pumped the low-pressure side down to zero pressure, until the steam pressure rises again.

Often, when the frost comes from one room very strongly, it may back up into all the other returns and then it is hard to tell by looking at them which is the one that is doing the damage, or if there are several returns giving trouble, which one freezes back the most. By wetting the finger tips and touching each return, the one that sticks to the fingers most readily is the one that should be turned off some. It is good practice to have marks of some kind on each expansion valve so placed that one can tell exactly how much was turned on or off.

If a refrigerating machine is to be stopped for a little while only, and the valves in the compressors are in good order, the discharge stop valves may be left open, but never the suction stop valve. This should be an engine-room rule.

Editorials

Driving Boilers and Burning Tubes

The author of the "Mechanical Engineers' Pocketbook" favors our correspondence columns with some observations upon our recent remark that "scale or oil which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface is very likely to make trouble when the evaporation goes up to six or ten pounds." He points out that with an average evaporation of three pounds per square foot per hour there may be times, as just before firing a fresh supply of coal, when the rate of transmission of heat may be equivalent to an evaporation greatly in excess of this figure. That is, one must not assume, because his boiler averages three pounds per square foot per hour, that it may not be working some of the time at the higher and more dangerous rate. His observation that the temperature of the fire is almost independent of the rate of driving seems to be irrelevant if it is the driving of the fire which is meant, but it is difficult to see, notwithstanding the reference to driving the boiler which follows shortly, how a hotter fire can be maintained without a corresponding increase in the rate of evaporation.

New York City's Proposed License Bill

It seems to be a never-ending duty of ours to remind engineers and legislators that some folks in this land are guaranteed a right to a livelihood by the Constitution of the United States, if not by the exercise of that sense of justice which civilized beings should manifest. If it were not so easy for those of the medical, pharmaceutical and other professions to kill the children of men, their possible victims would not require that they be certified by a license of competency. If steam boilers and engines were not veritable infernal machines in the hands of the unskilled, if they had not caused an appalling loss of life and property, the public would not seek to protect itself by inquiring into the correctness of their structure or the fitness of their operators.

Safety is the object, the end, the all, of such laws. But unfortunately, some engineers want to corner their local markets for engineers and to do it under the guise of public safety. They want to say to their fellow engineers: "Here, this territory is ours. No matter how badly you need a job, or how good the job is that you are after, or how competent you are to fill it, you cannot have it because you have not lived here one, three or a dozen years." It seems almost incredible that men should attempt to legalize and statutize their selfishness, yet they do. The laws of Buffalo and New York City are well known examples, but any law that denies the right of aliens to follow their trade or profession in any state, on the same footing as any citizen of that state, is unconstitutional and would be nullified the first time it was taken to court. Some engineers of New York City do not know this and have proposed a bill for the creation of a separate bureau in the department of licenses for the inspection of certain steam boilers and the examination and licensing of engineers and firemen. First, they wish to create the offices of superintendent of inspection, two general inspectors, two examiners, nine boiler inspectors, and other subordinates, and make all jobs appointive by the commissioner of licenses. It is not deemed advisable to examine into the competency of these appointees.

Applicants must be subjected to a physical and practical test of their fitness. The practical part is all right, but the physical test is nonsense.

A man must be twenty-one years old to get a fireman's license. Candidly now, how many of those who participated in the making of this bill were firing boilers before they were twenty-one? And do those who were believe now that they were not men enough for their jobs? Certainly not. That section of the bill is also ridiculous.

Worst of all is the section which states that "No such applicant (engineer) shall receive a license as engineer unless he is able to keep accurate data of the cost of operation and maintenance of boilers and steam machinery."

Much as we urge engineers to acquire such ability, we would not include its possession as a license-law requirement, for law is for safety, not to confer special privileges on certain classes, and safety does not depend on the knowledge above mentioned. Some men can operate plants safely who would make a poor showing before examiners as power-plant economists.

Surely, the engineers of New York City will kill this bill before its gets into Albany. Is it any wonder New York State cannot enact a state license law?

Specifying Unit Station Costs

In comparing the cost of generating plants it is always interesting to reduce the figures to the unit basis, but in many cases insufficient care is taken to specify just what units are in mind. In a typical instance the cost of an electric plant was found to vary from $45 to $125 per kilowatt, according to the selection of the factor divided into the total outlay in money. It is important in making such calculations to state whether one means cost per kilowatt of existing total rated capacity, cost on the basis of maximum sustained output for a protracted period of specified length, cost per kilowatt of plant completed to the ultimate capacity of the existing building, or whatever the factor of selection may be. Engineers are often a bit careless in this, with the result that figures do not always afford accurate deductions.

Sometimes, for example, a coal-handling equipment suitable for the proposed ultimate capacity of a given plant is provided long before all the engine or turbo units planned for have been installed. If the full cost of this

equipment is included in the unit determination for the station on the basis of perhaps a half of the ultimate number of generators and boiler batteries, one gets a different result from that obtained by making an allowance for that portion of the coal-handling plant required by present service and making a note to that effect on the estimate sheet.

Similarly, when a few units are housed in a building large enough for a substantial increase in capacity, one gets a relatively high building charge if a cost determination is made on the basis of the existing generating units. Figures of this kind are instructive and well worth assembling, but where they are prepared for an installation not yet complete according to the full plans, the fact should be made known in presenting unit cost data, so that a reasonable allowance can be made by those to whom the data are submitted.

It is often needless to attempt to separate that part of the cost of buildings or auxiliary apparatus such as stacks and condensing water tunnels chargeable to present plant from the ultimate station capacity cost, for in very large stations the boiler batteries and main units cost so much more than the auxiliaries that a considerable variation in the outlay for the latter produces but a comparatively small change in the unit result. That is, a building with sufficient house room to accommodate four 15,000-kw. turbo units and their necessary boilers will probably not cost enough more for the fourth unit to render valueless figures of unit outlay based on the total building space, even where only three machines are at first put in.

To return to the starting point, one may figure unit cost on any basis he pleases, and with profit, but unless that basis is definitely specified along with the figures deduced, misinterpretations and wrong comparisons are likely to spring up and cause trouble all around.

Concerning Expense Accounts

On the rare occasions when operating engineers are sent on business trips, they should realize the importance of their expense accounts. The way in which such accounts are rendered makes or mars the engineer's business reputation, and probably will affect his future advancement. Artists, scientists and even practical engineers are popularly considered as constitutionally unbusinesslike, and the more one studies the reasons for personal advancement, the more convincing is the evidence that clear-cut thinking and writing, methodical ways of doing things and an appreciation of the monetary side of affairs are powerful factors in the advancement of technical men to positions of executive responsibility.

The expense account is practically as important in the impression it makes upon the employer or superior officer as is the report of the engineer's trip. A man may go to a distant city, obtain the desired data, embody it in a valuable report and return home feeling that he has "made good" at the task in hand, but unless he turns in an expense account which can be roughly checked or audited by the man who "O. K.'s" the bill, he misses a real opportunity. A slovenly penciled memorandum of funds expended or a carelessly compiled group of items which yield no definite information as to the cost of main outlays, like transportation, hotel fare, cab or horse hire, telephone and telegraph expenses or important incidental disbursements made necessary by the trip, does the engineer positive harm.

The "boss" may not think anything about the matter, and then, again, he may. He may say to himself some time, "Johnson has gone over to Erie and got just the figures I wanted; he has put them down in the way I like; that fellow's got a clear head and his expense account shows that he has some business horse sense besides knowing a lot about steam engines and generators. I'm going to keep my eye on him and see if I can't work him up to take some of these details off my mind, and maybe make him assistant superintendent some day." There is nothing impossible about such a train of thought as this, and while it does not run through the individual employer's mind often, it is mighty important when it does—to the fellow who is striving to get ahead.

Needless to say, the right kind of a man will be as careful about squandering his employer's money as his own. This does not mean stopping at the cheapest hotels, for a first-class concern will wish its representatives to travel in reasonable comfort.

As one of the auxiliary matters, the proper handling of which will contribute to the sum total of impressions which lead to good repute, the engineer's expense account when away from home deserves thoughtful consideration.

Just for Fun

Send us the story of any piece of rank stupidity on the part of a power-plant employee that to your mind beats those in "Some Original Ideas," page 84. Just at present the fellow who gilded the commutator holds the palm. We do not wish to give much space to accounts of foolishness, but a limited number of the best letters received will be used. They will amuse all and instruct some perhaps.

Engineers' Study Course

The section on Power-Plant Design concluded with last issue. Four individual lessons not classified as a section, as were most of the previous ones, will appear, beginning with this issue, and these will end the Study Course, for the present at least. These last four lessons will be: "The Conversion of Energy" (page 103), "The Efficiency of Heat Engines," "Heat-Engine Cycles," and "Steam-Engine Cycles."

Those who bind their volumes of POWER, or who desire an index to facilitate reference to the filed copies, can have such an index by simply signifying their desire to the Subscription Department of POWER. An index is printed upon the completion of each half year, and is furnished free to all who care to have it.

Out in Ohio the following is what they require in an engineer-janitor:

> ENGINEER-JANITOR for large building; must be a man of good habits and willing to work, otherwise we cannot use you. State age, size of family, experience; give names and addresses of four responsible parties as references.

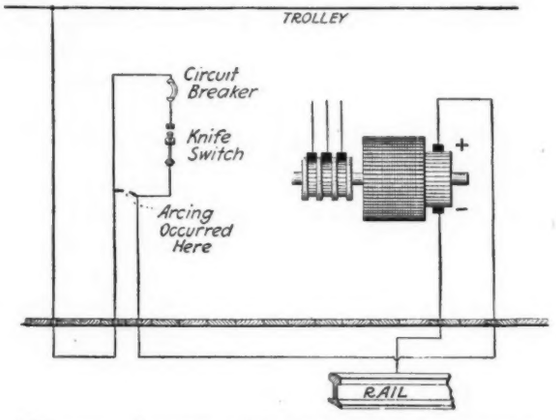
If this is a movement against race suicide we could suggest further qualifications with perhaps a little more emphasis on the "experience," for anyone in charge of a steam boiler has it in his power to reduce population.

Correspondence

Unusual Experience with Rotary Converter

During a severe electrical storm in northwestern Ohio an unusual phenomenon was produced by lightning on a rotary converter. The machine is part of a portable substation located in a box-car and which may be operated in parallel with the permanent substations on any desired section of the line.

No lightning protection was provided either on the 13,000-volt, alternating-current side or the 600-volt direct-current trolley side, the operator having instructions to shut down during lightning storms and pull all the switches.



DIAGRAM, SHOWING WHERE ARCING OCCURRED

At the beginning of this particular storm, the operator pulled all the switches, consisting of the high-tension alternating-current switch, low-voltage starting and running alternating-current switches, the direct-current circuit-breaker and switches, the field breakup switch and the shunt-field switch.

Following an intense flash of lightning, the converter started to run, the direction of rotation being reversed, and the speed increasing at an enormous rate. The insulation on the wiring back of the switchboard was afire and produced a dense smoke which cut off a view of the leads and connections. As the machine had acquired such a high speed that it was likely to go to pieces, due to the centrifugal force on the armature, the operator telephoned the power station and ordered the power off the lines. This was immediately done, whereupon the converter came to rest, after a long period. The fire back of the switchboard was then put out.

An inspection of the rear of the switchboard revealed the fact that the lightning had struck the trolley at some point in the near vicinity and the heavy rush of current accompanying it had punctured the insulation and arced across two leads which were close together on the back of the switchboard. One of these leads was from the trolley to the direct-current busbar and the other was from the direct-current side of the converter to the bottom point of the direct-current switch. The trolley-to-rail current maintained this arc and flowed to the direct-current end of the converter which started as a series motor with no load. The sketch will make this clear. The only damage inflicted was upon the insulation at the rear of the switchboard, the converter not being injured in any way.

FRANK W. SWIFT.

Toledo, Ohio.

Simplifying Reports of Boiler Tests

Mr. Morrison's letter in the Nov. 10 issue certainly touches upon a matter that requires to be put into clearer meaning than is usual at present. To simplify boiler reports, and make them of value to both directors and himself, the writer employs the following form:

Actual weight of water evaporated per pound of fuel (name of fuel).
Pounds of water evaporated for one cent.
Total cost to evaporate 1000 lb. of water, including labor.

Underneath for the writer's own information are:

Average percentage of CO_2.
Average temperature of feed water.
Average temperature of gases to chimney.
B.t.u. value of coal.
Amount of ash for given weight of coal.

With the first three items the directors can understand easily what the boiler plant is doing, and the remaining figures give the engineer all the particulars he really wants to know. If there are any peculiarities observed during the test, these are added in a footnote.

E. R. PEARCE.

Rochdale, Eng.

Suggested Use of Terms Vapor, Steam and Gas

The terms vapor, steam and gas as applied to the gas-like condition of water expanded by heat, although meaning the same thing, are, unfortunately, often used as though referring to things that differ in their properties. We read of steam pressure and vapor pressure; that water flashed into steam or vapor. Often in books the words vapor and steam are both used; perhaps to avoid the too frequent use of either word.

To one familiar with the definitions there is no mental effort required to connect the two with a single meaning, but to the beginners this practice is more or less confusing, and still more so by steam being sometimes called a gas.

I have recently asked a number of engineers what they understood by these terms. The majority had the correct idea, but some had a hazy impression of some difference. One said that he understood vapor to be that which was given off the surface of water at ordinary temperatures, or below 212 deg., and that steam was given off at above 212 deg. This man knew that the composition of both was the same as water, but thought the two terms were used as a convenience to distinguish the difference in tem-

perature. He understood the term gas to mean superheated steam.

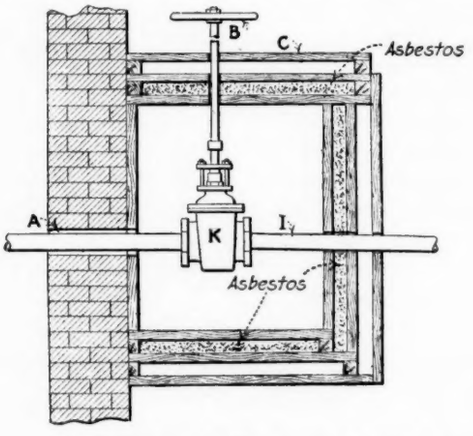
Now, if we must use the words vapor, steam and gas as applied to the expanded condition of water, it seems to me that the ideas of the engineer quoted would be more logical than mixing or using the terms interchangeably. We would then have vapor at temperatures below 212 deg., steam at above 212 deg. and gas as superheated steam.

C. O. SANDSTROM.

Kansas City, Mo.

Keeping Blowoff from Freezing

I overcame a difficulty similar to that described by A. T. Rowe, page 788, Dec. 1, at a place where the



BOX AROUND A BLOWOFF VALVE

temperature often drops to 30 deg. below zero. I built a double-walled box around the blowoff valve and filled the space between the walls with asbestos. The cover was inclined to allow the rain or snow to run off and was removable to give access to the valve when necessary.

A handle *B* is used to open and close the blowoff valve *K* without removing the cover. A space where the pipe passes through the wall at *A* admits a small amount of heat to the box. The pipe *I* has a slight slant so that no water can remain in it, and it has never frozen up during several years' use.

JAMES E. NOBLE.

Toronto, Ont.

Forcing Boilers and Bursting Tubes

In the illustrated article on "Burst Boiler Tube" in your issue of December 8, page 805, the statement is made that "scale or oil, which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface, is very likely to make trouble when the evaporation goes up to six or ten." This statement is apt to give an unwarranted sense of security to owners of boilers which are usually not driven at a rate of over three pounds evaporation per hour per square foot of heating surface. The fact is that when the rate of driving of a boiler averages this figure, there are times, when the fire is at its brightest, just before firing a fresh supply of coal, when the rate of transmission of heat may be equivalent to an evaporation greatly in excess of this figure.

Also, the rate of transmission of heat through the surface of the bottom half of the lower row of tubes, immediately above the fire, depends on the temperature of the fire, the temperature of the water in the tube, and the resistance to transmission of heat of any layer of scale or oil which may be on the surface of the tube. The temperature of the fire is almost independent of the rate of driving. It depends chiefly on the dryness of the coal, the completeness of the combustion, and the amount of excess air over that necessary to insure complete combustion. It is quite possible with either anthracite or semi-bituminous coal to have a temperature of 3000 deg. F. in the furnace, whether the boiler is driven at a moderate or at a high rate. Given a condition of firing which produces such a temperature, the rate of driving per square foot of heating surface depends upon the amount of heating surface that is provided for the absorption of the heat, and as this surface, or nearly all of it, is beyond the lower row of tubes immediately over the fire, it can have nothing to do with the establishing of a condition which would cause the burning out of a tube in the lower row.

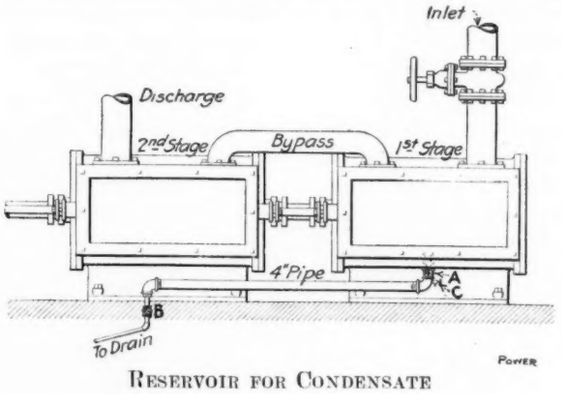
If statistics of burst boiler tubes should show that bursting is more frequent at high rates of evaporation, it does not follow that the high rate of evaporation in itself is the cause of the more frequent burstings. It is more probable that the greater frequency is due to the greater quantity of scale that is deposited in a given time when the boiler is driven at a high rate, and the conclusion to be drawn from this is that with high rates of evaporation it becomes necessary to use feed water that is purified before entering the boiler.

WM. KENT.

New York.

Water-Hammer in Vacuum Pump

We had considerable trouble by vapor being carried over from the surface condenser to the vacuum pump and causing water-hammer. It was necessary to stop the pump



RESERVOIR FOR CONDENSATE

and relieve the vacuum before the water would drain out, and as this usually occurred during the heavy-load period it called for fast work.

The quickest way was to slack off the valve-chest cover, but as the water accumulated to a dangerous extent, four or five times on a watch, it became a serious matter. To overcome this, I connected a 6-ft. length of 4-in. pipe, with a reducing elbow and a 1-in. globe valve at each end, to the bottom of the valve chest. Valve *A* at the

end next to the pump should be left open and *B* at the other end closed until water accumulates in the pipe; then *A* is closed and *B* opened to drain the water into the sewer. Pet-cock *C* is opened to admit air during the draining process. With a reservoir of this capacity, it is only necessary to drain out once in twenty-four hours.

F. O'Donnell.

Coscob, Conn.

Correction for Twisted Valve Stem

The diagram shown was taken from the high-pressure cylinder of a Corliss cross-compound condensing engine connected to a centrifugal pump. One valve stem was so twisted that the valve had a late admission, as shown, and the speed of the engine was reduced from 135 to 128 r.p.m.

After the key was taken out, the valve was turned until

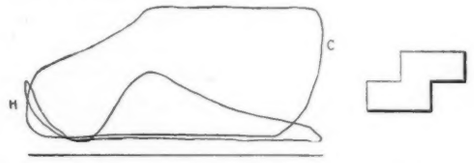


Diagram When Stem Was Twisted; New Key

it was in the right position and an offset key was made to suit the new position instead of turning the stem over and cutting a new keyway. The valve required no further adjustment.

Lawrence Kjeruiff.

Kansas City, Mo.

Improperly Finished Pumps

Referring to the letter on p. 892, Dec. 22 issue, under the above caption, I agree that stuffing-boxes are generally too shallow, but find that better results can be obtained with the bottom of the stuffing-box and the face of the gland square than at an angle. The packing should touch the rod from one end of the stuffing-box to the other with a moderate pressure over a large area rather than a concentrated pressure on a small area at the two ends, causing excessive local friction and wear.

I have designed and used many stuffing-boxes for steam, water and vacuum and have never had any difficulty with square faces. The operating engineer is quick to see the advantage of having each piece of packing in the box doing something like its share of the work. I have packed ½-in. reciprocating valve stems against 150-lb. pressure with soft packing in a stuffing-box 2½ in. deep. The glands were held by two ⅜-in. studs screwed up snugly with a small wrench, causing very little friction.

Good results have been obtained with a shallow stuffing-box having 30 deg. beveled bottom and gland face in packing a stationary pipe extending through a jacket against a steam pressure of 150 lb. In this case the stuffing-box was only 1 in. deep for ½-in. pipe, the object of the bevel being to obtain a tight joint in a small space regardless of friction.

E. P. Haines.

Baltimore, Md.

Large Saving in Hotel La Salle Plant

To anyone not acquainted with the facts, the attempt on page 63 of Jan. 12 to refute the article appearing in the Nov. 3 issue of Power might appear like an able defense of the former high cost of operation, but as a matter of fact it is misleading, to say the least. In the following reply it is the writer's intention to take each paragraph in turn and to give the facts in each case. Before doing this, I wish to state that the figures in Mr. Wilson's article are correct, and this statement is verified by the accompanying letter from the auditor of the hotel, who has held that position since February, 1910. The deductions made and the reasons given for the savings are also true in every respect. I know personally that it was not the author's intention to find fault in any way with my predecessor or his method of running the plant. There had been a difference in operating cost of $45,000 per year, and to tell how such an enormous saving had been made was the sole purpose of the article. This was done accurately. I do not take any glory unto myself for the saving, as in my opinion any engineer worthy of the name could have effected the same results by keeping on the job and by winning the full confidence of his men and his employer. Following is my reply, in which the numbered paragraphs refer to those of similar sequence in the preceding letter.

1. Mr. Lawrence admits that he was on the job 18 months before the hotel was opened. He had to pass on all the mechanical equipment before it was contracted for and also to O.K. the same before it was accepted. It was all contract work and all changes were up to the contractor. Certainly hotel help was not used to make contractor's changes. After the hotel opened all material and any labor done by the plant force which did not apply to the engineering department was charged to "Improvement and Betterments." The department was given credit and to the full amount specified by the engineer. Although Mr. Lawrence does not actually say that it was charged to his department, he infers that it was and overlooks the fact that the data given in the article do not go back of 1910. It will be seen in Table 2 of the article that the labor charges are practically the same for the four years given. The maintenance and supply items for 1910 and 1911 are excessive, due to lax operating methods, but the items are made up of legitimate power-plant charges.

2. By the present management it is also required that the house be thoroughly ventilated at all times, but as there were certain ventilating fans performing certain functions at different times, it was possible, by making a few changes, to arrange a schedule of fan operation which permitted shutting down some of the fans part of the time and the saving of considerable power. Under former conditions it was impossible to properly ventilate and cool one of the dining rooms until the air ducts had been enlarged and an additional fan installed, having a capacity of 6000 cu.ft. per min. During the summer months this room had been closed as it was so hot nobody could stay in it. For the past two years it has been open every day. Besides, a complete ventilating system has been installed in the laundry, where formerly there was no ventilation at all. All other fans are being run the same as ever, but only when needed and not haphazard as before. Instead of shutting down motors, except as before stated where they are run on schedule, three additional motors

have been installed in the laundry, two in the nineteenth-floor kitchen, one in the eighteenth-floor kitchen, and two in the sub-basement. Regarding cooling and refrigeration, a more even and lower temperature is maintained in the different rooms than ever before, and an additional 6000 cu.ft. of air per min. is supplied. This is not cutting down on service. The figures in the article also show that considerably more ice was made The machines are now operated on exhaust steam and not on live steam, as in former days. This is an item of saving. It is true that 25-watt tungsten lamps have been substituted in part for 16-cp. carbon lights. Any intelligent engineer would do the same, and it is inconceivable that any manager would refuse a better light costing less for maintenance and current providing he was properly informed of the facts.

3. The steam traps certainly did have an elaborate system of piping and must have been put in on the time and material basis. There were 15 on the high-pressure lines in the engine and boiler rooms. On the discharge line of each trap was a valve and between this valve and the trap a ¼-in. valve for detecting leakage of steam. Upon taking charge, I went to each trap, closed the valve in the discharge line and opened the try-valve. Without any exception, not water but steam under boiler pressure blew out. An investigation showed that the seats and valves of the traps were badly worn, and in some cases the valve was completely eaten away, giving a direct passage for the steam. The traps discharged to an open heater with cast-iron sections, and this in turn was connected with the expansion tank, from which risers to the heating system and the atmospheric exhaust were taken off. An employee who has been under both managements reports that on one occasion a repair was to be made to the heater. The valve between the expansion tank and the heater had been closed. Shortly afterward the latter exploded, and the cause was live steam from the traps.

4. It is common knowledge that as a hotel or any building gets older it requires more attention and especially more sweeping This is true in the present case, and the hotel is noted for its cleanliness. As stated, there are three vacuum machines of the inspirator type which use steam at boiler pressure and carry a vacuum of 12 in. On each machine is a control valve to automatically shut off the steam when the proper vacuum is reached. When the writer took charge all three machines were in operation and blowing continually without a sign of cut-off. The machines were overhauled, and it was found that one would do the work and still cut off intermittently. The same number of sweepers are in operation, and, as the hotel is getting older, more sweeping is necessary. One machine does the work very efficiently

5. These lights were installed during the summer before the writer took charge, for illumination during the roof-garden season. The same number of lights are still there and are burning every night of the season There is no change in the schedule. Instead of reducing the lighting it has been increased. An addition of 825 twenty-five-watt tungsten border lights has been made at the fourth floor, also 1350 ten-watt lamps in a large roof sign, and numerous table fixtures, each containing three 40-watt tungstens

6 Changes are continually being made, and more now than when I first took charge. The nineteenth-floor kitchen has been entirely remodeled and several additional steam-using appliances installed. A new kitchen has also gone in on the eighteenth floor, with coffee urns, soup heaters, steam tables, etc. Besides, a number of steam-using appliances have been added to the laundry. All of this work was done by the engineering department. Contrary to the inference made by Mr. Lawrence, the work was charged to "Improvement and Betterments" and the power plant was allowed a credit.

7. All engineers in Chicago know what it was to get coal in 1910, but that was only during the months of June, July and August. At that time I was in charge of a hotel plant three times the size of this plant and made a better showing than in the previous years. In Table 2 in the article the difference in the coal bills for 1910 and 1911 is $3500, which, divided by the tonnage for the year, amounts to only a few cents. Under conditions as I found them here, it was impossible to burn anything but a good grade of washed coal, as with inferior coal the combustible matter in the ash would be excessive. As to records, the boiler-room foreman who was on the job then and is still in the same capacity states that no records of coal were kept other than the amount of coal coming into the building; also that the water meter was out of repair continuously and was inaccurate, and before it could be used on the tests cited it had to be completely overhauled. Readings from it could not have been "absolutely correct," and it is rather difficult to see how the daily coal consumption could even be estimated with any degree of accuracy. Steam coming from the exhaust head on the La Salle, even on the coldest days, was a matter of comment among engineers of the city. Besides it is difficult to see how evaporation could be "kept up to the highest possible point at all times" with a CO_2 reading of 1½ to 2 per cent., which is all that could be obtained by the writer until the furnace conditions were changed.

8. To operate the electrical units at the best load factor, the same means were at the disposal of my predecessor. Even with the larger load he was carrying, due to inefficiency in more ways than one, it would not have been necessary to operate more than one unit at a time. In the very tests to which he refers a change of schedule was recommended, which would have effected a saving estimated at $15 per day, or $5475 per year. The two methods of operation were outlined in the article. I have followed the plan of operating the second unit from 7 a.m. to 5 p.m., the largest unit from 5 p.m. to 1 a.m., and the smallest the balance of the night. This allows each unit to operate at its highest efficiency and has proved a very flexible arrangement. All of the rooms are still cooled in the summer, as previously stated. Furthermore, hourly temperature readings are taken. By supplying an additional 6000 cu.ft. of air per min., it was possible to reopen the German restaurant during the hot months. This does not look like a discontinuance of service. The various services required have been maintained, but much more efficiently than in the past. As to the plant speaking for itself, I am willing to have it. I do not consider an engine room served by fluttering arc lamps well lighted. It now has clusters of 25-watt tungstens. All pipe joints and valve stems are kept packed and steam tight. When the writer took charge, there were leaks in the headers, stop valves, auxiliary valves, etc. In fact, on top of the boilers conversation was impossible, and in any part of the plant it could only be carried on under difficulties. The boiler tubes were in bad condition and a large number had

to be replaced. Water leaking at the ends of the fire tubes had mixed with soot and formed a hard deposit, half filling the tubes for a considerable portion of their length. The remodeling of the furnaces was accurately described in the article. Due to this it was possible to use an inferior coal costing less per ton. As to the condition of the engines, the following sentence of a letter from the builders to the writer will be illuminating: "I want to congratulate you on the nice running of your engines, which have undoubtedly taken time and great care to bring into line, as they have been fearfully abused."

9. Mr. Lawrence could not be expected to know that reliable tests have been conducted by the writer so that he knows exactly what he is doing in the plant and furthermore that accurate daily records are kept of coal and water. As to the tests mentioned by Mr. Lawrence and printed in part in his letter, I have nothing to say. There is no occasion to bring another party into the controversy, and for that matter it is not necessary, as the results obtained speak for themselves. These were given accurately in the article by Mr. Wilson, as well as a careful analysis of how the saving was effected.

10. In the article appearing in the Nov. 3 issue, the size of the new elevator pump was given, but no special reference was made to it as it was not installed until last August. The latest records given in the article were for the year 1913. As to the necessity of installing this pump, it may be stated that the three pumps originally installed had to be maintained in service from 6 a.m. to 12 midnight, and at times under the former management they were so hard pressed that it was a common occurrence for the accumulator to hit the bottom, nearly wrecking the duplex pumps before the attendants could reach the throttle. Apart from better elevator service, the new pump has effected a saving in coal, as the coal costs for corresponding months in 1913 and 1914 will show:

COAL COST PER MONTH

	1913	1914
August	$3159.09	$3059.10
September	3198.62	3046.52
October	3471.41	3128.93
November	3229.66	2898.28

In August the pump was only run two weeks, as the builders still had some work to do on it. In September and October, it was run three weeks each month and in November nearly four weeks.

The new hot-water heater was badly needed. Before it was installed, it was necessary to carry 3 to 4 lb. back pressure on the entire system to furnish enough hot water for bathing, and even then there were many complaints over the low temperature of the water. The new heater has done away with this trouble, and the building can be heated by steam under a pressure of 1 lb.

The above covers all points brought up by Mr. Lawrence. Numerous other items might be mentioned to show how the saving given in the article was effected, and if desired the writer can go into fuller detail at a future date. It will be of interest to notice in the auditor's letter that the saving last year was even greater than in 1913, and more work has been done than ever before.

W. W. BIRD,
Chief Engineer, Hotel La Salle.

Chicago, Ill.

I have served the Hotel La Salle Co. in the capacity of auditor since February, 1910, and to the best of my knowledge the charges made to the engineer's department during the periods shown in Table 2 of the Nov. 3 issue of POWER were all legitimate charges to that department.

When the services of the engineer's department have been required for changes or additions to construction, full credit has been given on the company's books for time and materials used.

It should be noted that your correspondent particularly refers to the period of September to December, 1909, whereas the Nov. 3 issue of POWER gives no figures whatever for that period. It may be that he has some specific item in mind, and if such is the case, I would be glad to investigate and report on it after hearing from him.

It might interest your readers to know that further economies effected in the engineer's department during the year 1914 make a still more favorable comparison with previous years' operations, especially in view of the continued increase in the hotel's business.

W. H. PETERKEN,
Auditor, Hotel La Salle.

Chicago, Ill.

Detecting Ammonia Leaks

In the Dec. 15 issue, Mr. Anderson takes exception to my method (see Nov. 3 issue, p. 656, under Robert G. Thurston) of detecting ammonia leaks in brine tanks. His method is to empty the tank, get inside it and test the coils with a sulphur stick while the pressure is on the coils. This is the best method, but how many engineers are going to take the trouble to pump out the tank, crawl inside of it while it is cold and slimy and conscientiously apply the sulphur stick to every joint? There are few. I agree with Mr. Anderson that there will be a few pounds of ammonia lost by using my method, also that the sulphur stick will locate ammonia leaks more readily than litmus paper or Nessler's solution, but when he claims that he can detect ammonia in brine by smell before it can be detected with litmus paper or the solution, I must say I am skeptical.

Mr. Anderson states that to test the brine-tank coils properly one should reduce the pressure to 5 lb. before testing. The higher the pressure the more prominent the leak and the more readily it may be detected.

The use of the words "discharge tanks" in my article is wrong. The manuscript read "discharge lines."

Mr. Anderson claims that some losses are due to the disintegration of the ammonia. This is questionable.

Water should not be present in the ammonia in a properly managed compression plant. In an absorption plant it is of course different. Many operators claim that running with cold rods draws moisture into the cylinder with each stroke of the machine, due to the moisture clinging to the cold rod and being drawn in with it. I have seen considerable water get into the system with the oil by using the oil over again and not having it properly filtered. Moisture will also get into the system when the expansion coil or suction line is opened and left open; the moisture precipitates on the cold surfaces and accumulates in the pipes and when the system is put in operation again is swept along with the ammonia.

If steam is used to clean the oil out of the system and it is not thoroughly blown out with air afterward, the condensation will remain in the pipes.

THOMAS G. THURSTON.

Chicago, Ill.

Inquiries of General Interest

Inspection of Storage Batteries—How often should storage batteries be inspected?

C. E. C.

It is well to thoroughly inspect them at least once a week, using a special lamp for the purpose.

Bar-to-Bar Test of Armature—When making a bar-to-bar test of a dynamo or motor, what would a sudden drop of milli-volt reading indicate?

Z. H.

A sudden drop in the reading would indicate a short circuit, either between the bars themselves or between the windings connected to the respective bars.

Pitting Due to Presence of Fatty Acids—What would cause oily feed water returned from an exhaust steam-heating system to pit boiler tubes?

R. M. C.

Pitting might be due to fatty acids contained in animal or vegetable oil used as an adulterant of the engine cylinder oil.

Anchor Ice—What is anchor ice and how is it formed?

R. C. M.

Anchor ice or ground ice consists of needles and thin scales of ice which form in moving water and sometimes on the bottom of still water. They usually cease to form after the body of water has become frozen over. On coming in contact with submerged objects these particles of ice adhere and soon form large masses difficult to dislodge.

Quality of Steam Gathered near the Surface of the Water—What would be the quality of steam gathered in a petticoat pipe near the surface of the water in a boiler as compared with steam taken from the top of the boiler?

J. E. N.

In the process of ebullition the globules of steam, in rising from the body of water to the surface, entrain water which is unevaporated and which is projected above the surface of the main body of water. Unless the steam is superheated there will generally be some water thus entrained that will be carried to every part of the steam space of the boiler. It is usually the case that the nearer the disengaging surface of the water, the larger will be the proportion of water thus entrained by the steam, hence steam gathered near the surface of the water by a petticoat pipe would be much wetter than steam taken from the top of the boiler.

Changing Governor Pulley—A belt-driven governor regulates the speed of an engine to 80 r.p.m. The governor driving pulley on the main shaft is 12 in. diameter and the receiving pulley on the governor is 7 in. diameter. To what size should the governor receiving pulley be increased to regulate the engine to 90 r.p.m.?

With 80 r.p.m. of the engine the speed of the governor pulley is $\frac{80 \times 12}{7}$ r.p.m., and as practically the same speed of governor would be required, then for regulation at 90 r.p.m. of the engine shaft, the governor receiving pulley should be

$$(90 \times 12) \div \left(\frac{80 \times 12}{7}\right) \text{ or } 7\tfrac{7}{8} \text{ in. diameter.}$$

Original Babbitt Metal—What was the original recipe for babbitt metal?

L. J.

The original recipe proposed by the inventor, Isaac Babbitt, a brass founder, of Boston, Mass., was 4 lb. of copper, 8 lb. of antimony and 24 lb. of tin = 36 lb. of mixture called hardening, and to every pound of hardening 2 lb. of tin was added, so that the completed mixture was in the proportions: 4 lb. of copper, 8 lb. of antimony and 96 lb. of Banca tin or 1 : 2 : 24. For making the alloy the melting must be gradual or the antimony and tin will largely separate from the copper and form oxides or dross on the surface. Thus 4 lb. of copper is melted first, then 12 lb. of tin and 8 lb. regulus of antimony are added slowly to the molten copper, to which 12 lb. more of tin is added to form the hardening. Then for use with each pound of this, 2 lb. of Banca tin is melted. The surface should be covered with pulverized charcoal and a small portion of sal ammoniac. Previous to pouring the mixture it should be well stirred.

Evaporation per Pound of Fuel Oil—What would be the rate of evaporation per pound of fuel oil having a calorific value of 18,500 B.t.u. per pound with a boiler efficiency of 75 per cent., a steam pressure of 50 lb. gage and a feed-water temperature of 135 deg. F.?

S. F.

With 75 per cent. boiler efficiency there would be

$$0.75 \times 18{,}500 = 13{,}875 \text{ B.t.u.}$$

realized per pound of fuel. As each pound of feed water raised to 50 lb. gage pressure, or about 65 lb. abs., would contain 1178.5 B.t.u. above 32 deg. F., and as with feed water at 135 deg. F., or 135 — 32 = 103 deg. F. above 32 deg. F., each pound would receive 1178.5 — 103 = 1075.5 B.t.u., then $\frac{13{,}875}{1075.5}$ or 12.9 lb. of water would be evaporated per pound of fuel.

Effect of Temperature on Wire Resistance—If the resistance of 1000 ft. of copper wire at 75 deg. F. is 100 ohms, what would be the resistance per foot at 90 deg. F.?

R. J.

The resistance of copper wire increases with an increased temperature. The formula to be employed is:

$$R_2 = R_1 + C \times R_1 (T_2 - T_1),$$

where

R_2 = The resistance, hot;
R_1 = The resistance, cold;
C = The temperature coefficient, depending upon the metal, which in the case of annealed copper averages about 0.00223;
T_1 = Temperature, cold;
T_2 = Temperature, hot.

Hence, where the resistance of 1000 ft. of copper wire at 75 deg. is 100 ohms, the resistance per foot at 90 deg. F. would be

$$R_2 = 100 + 0.00223 \times 100\ (90 - 75)$$
$$= 100 + 0.223 \times 15$$
$$= 103.345 \text{ per 1000 ft. or } 0.103345 \text{ ohms per ft.}$$

Connecting Ground Circuit of Generator—At what point in the armature of a three-phase generator would it be proper to connect the ground circuit for the generator to operate on a grounded neutral system?

A. R. P.

If the generator is star connected, ground the neutral as in Fig. 1, in which case the maximum potential to ground will be 58 per cent. of the line voltage. If delta-connected,

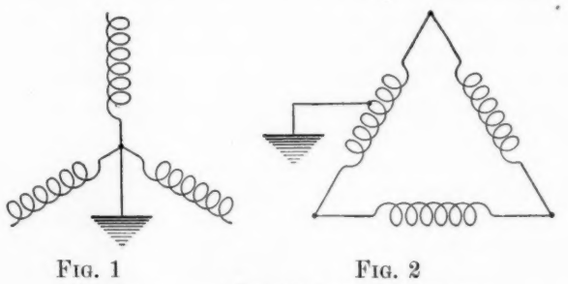


FIG. 1 FIG. 2

METHODS OF GROUNDING GENERATOR

one side may be grounded as in Fig. 2, in which case the maximum potential to ground is 87 per cent. of the line voltage. The ground may be direct, or through resistance or reactance, the latter limiting the flow of current.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

The Conversion of Energy

All the activities of power plants depend upon the general fact or law of nature that the different kinds of energy can be converted one into another. In these activities four kinds of energy are involved: Chemical, thermal, mechanical and electrical. Selection by twos gives the following combinations, as illustrated by one or more practical examples:

Chemical energy to heat: Combustion in boiler furnace or in engine cylinder (a).

Chemical to mechanical: No direct conversion, heat energy coming between.

Chemical to electrical: Electric battery, particularly the storage battery (b).

Heat to chemical energy: Dissociation of water or carbon dioxide in boiler furnace or gas producer, also operations of reducing metals from their ores (b) or (c).

Heat to mechanical work: All kinds of heat engines (c).

Heat to electricity: Only such feeble activity as that of the thermocouple.

Mechanical work to chemical energy: None.

Mechanical to heat: Compression, friction, impact, etc. (a).

Mechanical to electrical: The electric generator (b).

Electrical to chemical: Electrolysis, as in charging storage batteries (b).

Electrical to heat: Electric lighting and heating; use of a rheostat as load for a generator, when testing (a).

Electrical to mechanical: The electric motor (b).

Three of these combinations, namely, chemical to mechanical, mechanical to chemical, heat to electrical, are either absolutely or practically impossible except through some intermediate transformation. The other nine are divided into three classes, indicated by the letters (a), (b), (c).

Class (a) comprises the transformations which are or can be complete, every one having heat as its final state. The fact that the whole of the fuel may not be burned in a furnace or engine does not qualify the completeness of energy conversion for what is burned, and under special conditions, as in the fuel calorimeter, complete combustion is surely obtained. In the conversion of other forms of energy into heat an efficiency of unity is, therefore, attainable.

The transformations in class (b) have unit efficiency as an ideal limit, which may be approached but never quite attained. To these interchanges between chemical and electrical and between mechanical and electrical energies should be added the transmission of mechanical work and its change in form by machinery. The efficiency of most machines lies within the range of from 70 to 95 per cent. A large generator or motor will go a little above 95 per cent. The perfect generator, motor or storage battery cannot be realized, but it is easily imaginable and can be quite closely approximated.

Notice particularly that all the energy not usefully converted in the operations of class (b) is changed into heat and thus wasted.

Last comes class (c)—the conversion of heat into some other form of energy, and especially into mechanical work; in other words, the question of heat-engine operation and efficiency. The outstanding fact in this field is the impossibility of anything approaching complete conversion. Within the limits imposed by natural physical conditions, there is no known or imaginable method or scheme of working by which a heat engine can change into work the whole of a given amount of heat supplied to it. Necessarily, such an engine converts but a portion of the heat received and gives up the remainder as heat in an inconvertible state. Its limit of efficiency is not 100 per cent., but some fraction which, with varying conditions, ranges from perhaps 15 to 65 per cent. To reason out the character of this limit and establish its value is one of the important tasks of the science of thermodynamics.

After the descriptive statements which have just been made, and keeping in mind the power-plant point of view, the following summary will appear rational:

Chemical, mechanical and electrical energies may be put in one class, and are sometimes called the higher energies. Heat is a class by itself and is a lower form of energy, especially when it has sunk into a state of low temperature or intensity.

Then the different types of conversion classified as (a), (b) and (c) may be briefly defined as follows:

The higher energies can be completely converted into heat. They also have certain interconvertibilities, in which the efficiency may approach, but can never attain to, unit value. And what is not usefully converted is lost as heat.

By certain processes heat can be converted into the higher energies, but only in part, since there is always a large remainder of energy left in thermal form.

Finally, the tendency in nature is for all kinds of energy to sink into the form of heat of low temperature.

Relative Efficiency of Steam, Gas and Oil Engines—Roughly stated, a first-class modern steam engine utilizes about 12 per cent. of the available heat in the coal, resulting in, say 1.6 to 1.7 lb. of fuel per b.hp.hr. during a week's work of 55 hr. If the boilers are to be fired by producer gas, for which purpose slack and dust can be used, then each brake horsepower will require about 2 to 2.2 lb. of coal. Internally fired gas and oil engines are approximately twice as efficient as steam engines, which means that they utilize about 25 per cent. of the available heat. Crude oil being 37 per cent. better than good ordinary coal, oil engines should use only about three-eights as much oil as the coal mentioned above, say about 0.6 lb. per b.hp.-hr. Then, however, as there are no boiler radiation losses over night, a material saving results and the oil consumption per week of 55 hr. may be about 0.5 lb. per b.hp.-hr. Petrol and similar internal combustion engines would require about 0.4 lb. per b.hp.-hr. Gas engines have also about the same efficiency as oil engines; but as there is a loss of about 20 per cent. in the producers, if these work day and night, and another loss of quite 10 per cent. if they have to stand idle over night, the efficiency of gas engines is only about 40 per cent. better than that of first-class steam engines.

Design and Operation of the Cleveland Municipal Electric Light Plant*

By Frederick W. Ballard

The new Cleveland, Ohio, municipal lighting plant, known as the East 53d Street Station, went into operation July 20, 1914. It is the largest central station in this country built by a municipality, and is intended not only to supply electric current for street and commercial lighting, but also for power users. The rates charged for the service range from $0.03 per kw.-hr. maximum to $0.01 per kw.-hr. minimum. This station has a capacity of 25,000 kw. and is at present loaded to one-fifth of its capacity.

The estimated results which will be secured from the new 25,000-kw. station, which has just been placed in operation, are based upon an annual output of 60,000,000 kw-hr. and with fixed charges founded upon a total plant investment of $3,000,000. Fixed charges amounting to 9 per cent. on this investment would equal $0.0045 per kw.-hr. Cost for coal is estimated at $0.002 per kw.-hr.; station costs exclusive of coal at $0.0015; distribution costs exclusive of fixed charges at $0.004; administration charges at $0.005, and profits at 8 per cent. on the investment at $0.004. This makes an average price to be secured per kilowatt-hour generated of $0.0165. From the three months' operation of this station, together with tests that have been conducted, the indications are that these estimated results will be secured.

The plant was built from the proceeds of a $2,000,000 bond issue by the City of Cleveland, about one-half of this amount being invested in the station itself. The other half is to be invested in the substations and in the distribution system, including overhead and underground lines. In addition to the $2,000,000 derived from this bond issue, there are also available the proceeds of a $500,000 bond issue voted by the City Council to supplement the original bond issue, making a total amount of $1,500,000 to be invested in the distribution system. The value of the present distribution systems connected with the Brooklyn and the Collinwood stations is about $500,000, making the total value of the East 53d Street Station, together with its distribution system, about $3,000,000.

The results which have already been obtained in the operation of the Brooklyn lighting station and the East 53d Street Station during the first eight months of the year 1914 tend to substantiate the original estimates of what will eventually be secured in connection with the operation of the East 53d Street Station. A statement of revenue and expense connected with the operation of these two stations for the first eight months of the year is as follows:

TABLE 1—REVENUE AND EXPENSE STATEMENT FOR FIRST EIGHT MONTHS, 1914

Revenue from sale of current for first eight months of 1914	$153,363.65
Kw.-hr. generated, 7,863,610; average sale price, $0.0195.	
Kw.-hr. sold, 6,270,726; average sale price, $0.0244.	
Operating and maintenance for first eight months	97,044.60
Kw.-hr. generated, 7,863,610; average cost price, $0.0123.	
Kw.-hr. sold, 6,270,726; average cost price, $0.0154.	
Net earnings for eight months	$56,319.05

The total kilowatt-hours generated for eight months is greater than the output for the year 1913. The average cost price per kilowatt-hour generated is $0.0123, as compared with $0.0149 for the previous year. The results secured in the way of operation and maintenance costs in the power station itself for the months of August and September are shown in Table 2:

TABLE 2—EAST 53D STREET POWER STATION REPORT, AUGUST AND SEPTEMBER, 1914

	Aug.	Unit Cost	Sept.	Unit Cost
Operation—				
Labor	$1498.48	$0.0018	$1573.00	$0.0017
Switchboard attendance	352.80	0.0004	380.00	0.00042
Oil, packing and waste	....	.....	66.89 }	0.00008
Sundry expense	....	.....	10.46 }	
Coal	2686.50	0.0033	2415.69	0.0026
Maintenance—				
Condensers, piping, etc.	5.48	.....	.....	.....
Total operation and maintenance	$4543.26	$0.0056	$4446.04	$0.0048
Total kw.-hr. generated	809,120	.....	914,850	.....

*Excerpts from paper read at the annual meeting, December, 1914, in New York City, of the American Society of Mechanical Engineers.

The East 53d Street Station during these two months has been operating at less than one-fifth of its total capacity. The figures representing unit costs for the various items of labor, maintenance, fuel, etc., are considerably higher than should obtain when the station is running up to its capacity, when it will be operating at a much higher efficiency in regard to coal consumption per kilowatt-hour, and also the labor and other charges will be less per unit cost by reason of the larger output. During the month of August, the output of the Brooklyn and East 53d Street Stations amounted to 1,117,920 kw.-hr., of which 936,467 kw.-hr. was sold to customers, giving a loss in transmission of only 16¼ per cent. The average sale price for the kilowatt-hour generated was $0.0174, while the average sale price of what was sold was $0.0207, the revenue for the month being $19,405.38.

That an average load factor of 40 per cent. will be secured on this station when the load is built up to its ultimate capacity seems to be assured, and the indications are that a better load factor will be obtained. A typical load curve is only 2700 kw., but with a load factor of 80 per cent. based on the peak load there is a total output on the generating station of 51,925 kw.-hr. If these conditions can be maintained or even approximated when the load on the station has been built up to its ultimate capacity, the load factor will be considerably greater than 40 per cent. The location of the station was determined mainly by the convenient and economical facilities for delivering coal and also by the possibility of securing the cheapest and best water for condensing purposes. The Water-Works Department has a 9-ft. tunnel extending five miles into Lake Erie and draws water at this point from 125 ft. below the surface. This water, after passing through the surface condensers in the power plant, passes on to the suction chambers of the water-works pumping engines. The increase in temperature of the water going into the city mains, it is estimated, will not exceed 1 deg. F. In this way the lighting plant has not only secured the cleanest and coldest water for condensing purposes possible, but has also made use of a plant calculated to obviate any possibility of interruption by clogging of the inlet with ice or débris floating in the lake.

The coal question was considered as of next if not of equal importance to that of water. As the Lake Shore & Michigan Southern Ry. tracks run along the southern line of the property, with an elevation of about 60 ft. above the lake level, a method of handling the coal almost entirely by gravity has been worked out. Fig. 1 is a cross-section of the station in detail, wherein the coal is delivered overhead by the railway cars and is discharged by gravity into 3400-ton capacity bunkers, from which it is drawn through gates under pneumatic control into an electric telpher, which moves back and forth from under the bunkers on the track leading out over the stoker hoppers. The coal hopper on this telpher is carried on scale beams, and the weight of the coal and the time of delivery are recorded.

The special features in connection with the design of this station different from standard practice are as follows: The use of motor-driven auxiliaries throughout the plant; large boiler units with high steam pressure; economizers of greater capacity than ordinarily installed; a new arrangement of coal-handling apparatus; the use of both forced and induced draft with practically atmospheric pressure in the combustion chamber; automatic control of furnace conditions; simplicity of the piping layout, due to motor-driven auxiliaries; and the use of an auxiliary steam turbine for driving the auxiliary motors. This turbine is supplied with a jet condenser, the cooling water for which is used as boiler feed water after being passed through the economizers.

The practice of using motor-driven auxiliaries has not been adopted in this country principally for two reasons—(a) the use of exhaust steam from the steam-driven auxiliaries for feed-water heaters has been considered advisable as giving sufficient economy to warrant the use of steam, rather than motor-driven auxiliaries, and (b) the operation of the auxiliary equipment in the station by current from the main generators has been considered to introduce an element of uncertainty and unreliability into the service which it would be better to avoid.

To the first objection it can be stated that the thermal efficiency of the station can be shown to be higher when the

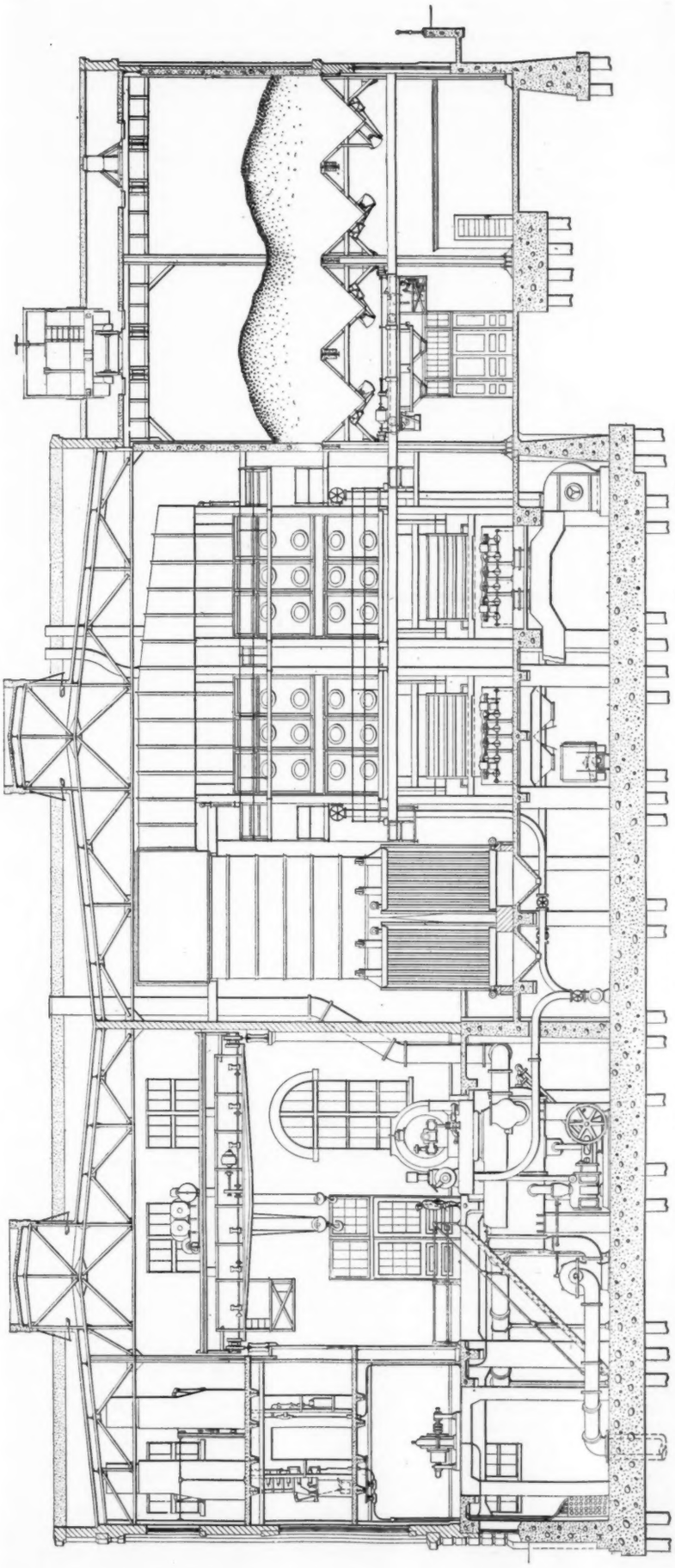


FIG. 1. CROSS-SECTION OF THE CLEVELAND MUNICIPAL LIGHTING PLANT

auxiliaries are motor driven and the heat for the boiler feed water is secured by the use of economizers from the flue gases. No arrangement of steam-driven auxiliaries would give just the proper amount of exhaust steam for heating the feed water properly at all loads on the station. There would always be periods when there would be either not enough or too much steam, and some would go to waste. There is also the complexity of steam piping necessary for supplying the auxiliary engines, with the incident losses from radiation and leakage. The second objection is answered by the installation of an auxiliary steam turbine. A 1000-kw. turbine with an overload capacity of 1500 kw. has been in operation in the Brooklyn Station for years and is now in good condition. This machine will be removed to the new station.

This machine will be operated in connection with a jet condenser, the cooling water for which will be drawn from a cistern which is used for the storage of the boiler feed water for the station. This cistern is divided into two compartments by a wall, the top of which is about two feet below the surface of the water. On one side of this wall will be the cold well and on the other side the hotwell. The condensate from the three main turbines will be discharged into the cold well and carried to a point near the bottom, where is located the suction end of a pipe carrying the circulating water to the jet condenser. The discharge from the jet condenser will be carried to the other side of the cistern, or the hotwell, and delivered at a point near the suction end of the pipe carrying feed water to the boilers. The makeup water for the system will be delivered into the cold well at the same point as the discharge of the condensate from the main turbines. The makeup water will be under control of a float valve designed to maintain the level of the water in the cistern at the required height.

It is not the intention that the quantity of water flowing through the feed piping system to the boilers shall determine the volume passing through the jet condenser as the volume of circulating water will be several times greater than the quantity of feed required by the boilers. The water in the cistern will, therefore, pass through the jet condenser several times before it goes as feed water to the boilers, and to prevent a uniform temperature throughout the cistern and a consequent lower vacuum in the jet condenser, the arrangement of hotwell and cold well was provided, and the piping was connected in such a manner as would supply the coldest water to the condenser and the hottest water to the boiler-feed system.

The auxiliary motors in the station will all be connected through a double bus system, so that each motor can be operated either by current from the auxiliary turbine or from the main generator. In this way the load on the auxiliary turbine can be adjusted so that the temperature of the feed water will be that best suited for delivery to the economizers. This temperature should be approximately 120 deg. F. If much less than this amount, the economizer tubes will scale with soot and cause trouble. If a greater temperature than that necessary to avoid this trouble is secured, there will be a sacrifice of economizer efficiency. Fig. 2 is a floor plan of the plant.

The use of large boiler units with high steam pressure was decided upon. The boilers ultimately installed were similar

to those in the Delray Station in Detroit, and the dimensions are identical, except as to the length of the drums. These boilers (Fig. 3) each have 10,000 sq.ft. of heating surface and are designed to carry 275-lb. working pressure with a superheat ranging from 125 to 150 deg. F. They are equipped with underfeed stokers and are intended to be capable of operating up to 300 per cent. of rating.

The operation of the boilers at a high percentage of rating means a higher temperature of flue gases. This, with the low temperature of feed water, gives a temperature head between flue gases and feed water which will be practically double that ordinarily obtained in economizer practice. This alone would be sufficient to warrant a larger amount of economizer heating surface than would ordinarily be deemed advisable. However, there is another factor in the Cleveland situation which also warrants an increase in the economizer capacity. In economizer practice, the interest on the investment, generally figured at 6 per cent., is balanced against the saving which will be produced in the economizers, but in municipal engineering it is found that interest on the investment can be figured at 4½ per cent. instead of at 6 per cent. This fact alone would warrant an increased capacity in the economizer. Taking these factors into consideration, it was thought that a conservative estimate on economizer requirements would be 27,000 sq.ft. of heating surface. They are arranged in two parallel sections, independently, so that either section can be cut out by means of dampers for cleaning and repairing, leaving the other in operation.

The use of both forced and induced draft contributes to the flexibility of the installation and makes it possible to carry practically a balanced pressure in the combustion chamber, thus avoiding one of the greatest sources of loss in boiler practice, the leakage of air through the boiler settings. Two induced draft fans were put in, either of which has a capacity for taking care of the peak load requirements of the station. A separate forced-draft fan with an individual motor drive was placed in the boiler room basement for each furnace. The motors on the forced-draft fans are under automatic control, and their speed is governed by means of rheostats controlled by the boiler pressure. The motors for operating the stoker feed are also controlled by rheostats governed from the pressure in the air ducts underneath the boilers. The induced-draft fans are under manual control, and their speed is intended to be regulated by the man operating the boilers so as to give the proper draft for holding practically an atmospheric pressure in the furnaces.

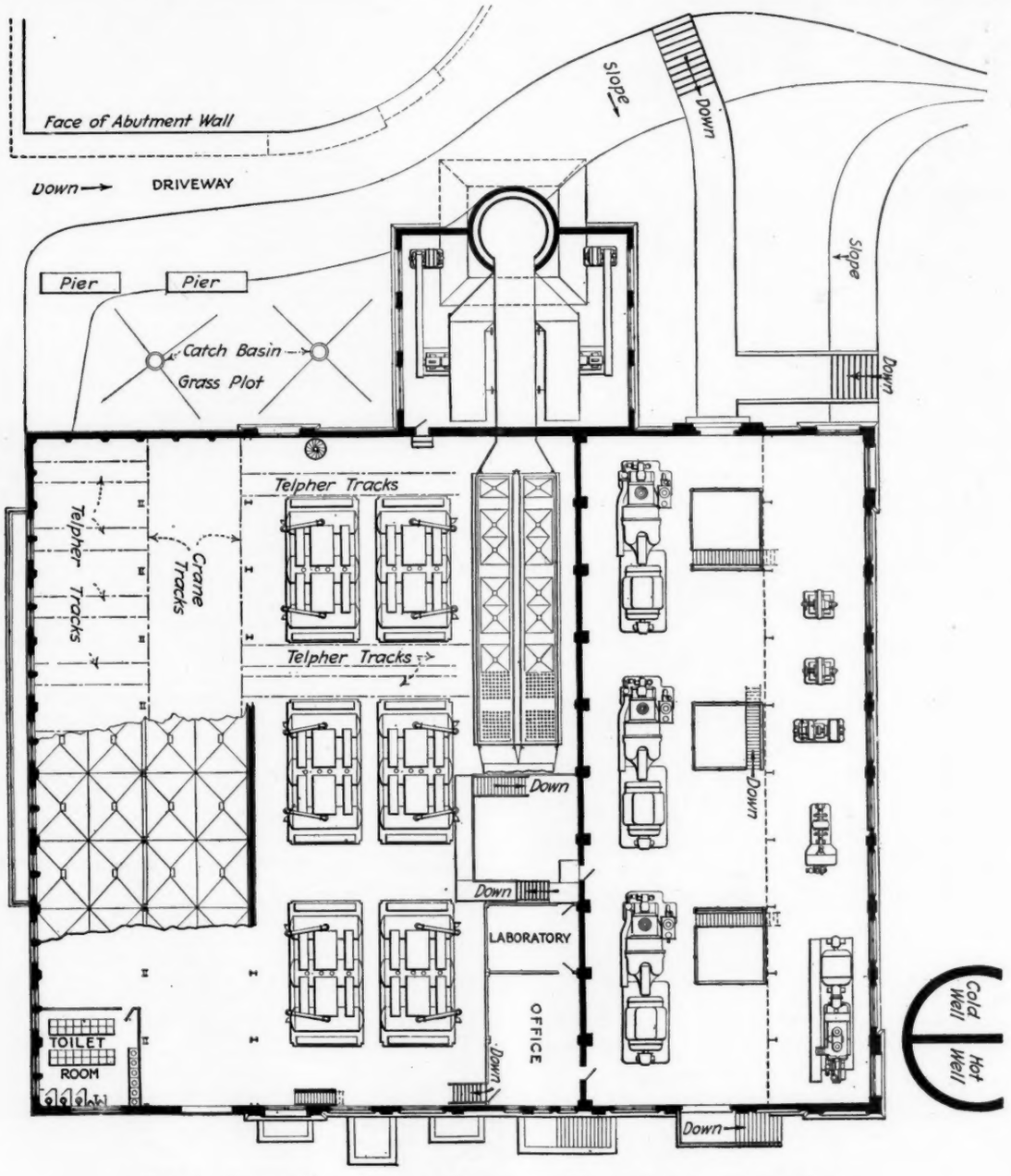


FIG. 2. FLOOR PLAN OF THE CLEVELAND MUNICIPAL LIGHTING PLANT

The steam piping is simple, because, outside of the auxiliary turbine and the emergency equipment consisting of a steam-turbine exciter and a turbine-driven feed pump, steam will be used only in the main generators. The plant is so arranged that each battery of two boilers is opposite one turbine generator, the steam lines from the boiler going to the header, from which a short branch is taken to the turbine. The header is capable of being cut into three sections by means of Hopkinson-Ferranti valves, with operative working parts of half the diameter of the steam main. The interior of these valves is shaped like a Venturi nozzle; they will pass an amount of steam equal to the full carrying capacity of the pipe with practically no reduction in pressure. The main steam header is located in the boiler-room basement near the floor, and the piping is arranged so as to drain to this header from all directions. This header is 135 ft.

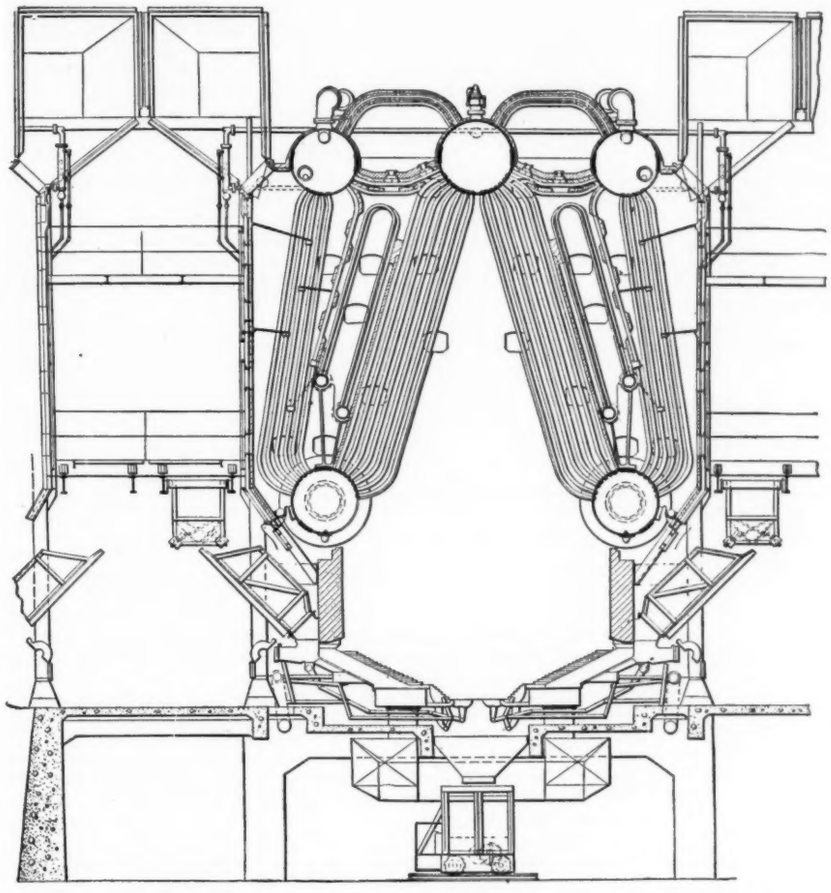


FIG. 3. SECTION THROUGH ONE OF THE BOILERS HAVING 10,000 SQ.FT. OF HEATING SURFACE

long and designed for the minimum of expansion which would effect a lateral movement in the branch pipes. It is divided in the middle by an expansion bend, which consists of two short headers carrying four small U-shaped pipes of only one-half the diameter of the main. Two halves of the main header are then anchored securely at their central points and carried on rollers from this point in both directions. This then divides the main header in such a way that at no place would the movement caused by expansion be more than that due to the expansion in one-fourth of its length. The main steam header is only 14 in. in diameter and is composed of ⅝-in. thick steel pipe with welded necks and flanges. The branch pipes contain no fittings except the valves, which are of heavy cast steel. All turns are of long bends and all sections have welded flanges.

The feed-water pumps are all centrifugal. Two are constant speed and motor driven. One is steam-turbine driven and is designed for emergency purposes and for operation when no electric current is available. This pump is arranged with governor control for constant pressure and is therefore capable of being used in connection with either of the motor-driven pumps and to supply water to the boilers only when the demands are in excess of the capacity of the other pump.

In the chief engineer's office are located indicating and recording instruments for practically every operation in the station. There is a graphic recording totalizing watt-meter which gives a continuous record of the combined output of the station. The amount of feed water going to the boilers is shown by the indicating dial of a V-notch recorder, which also gives a continuous graphic record and the total quantity by means of integrating dials. The CO_2 in the flue gases is recorded, and recording thermometers keep record of the temperature of the feed water entering and leaving the economizer and the temperature of the flue gases in the boiler breechings as well as at the discharge end of the economizer. The steam pressure and the temperature of the steam in the main header are also recorded, thus giving a record of the superheat. This information, together with the record of the weight of coal going to each boiler, which is turned in to the chief engineer at the end of each 8-hr. shift, enables him to have a complete log of the performance of the station made up every day.

The use of 11,000 volts removes the necessity of having rotary converters, the absence of which is particularly notable when compared with the prevailing practice of supplying the congested districts of large cities from numerous substations in which there are placed rotary converters for changing alternating into direct current.

DISCUSSION FOLLOWING THE PRESENTATION OF MR. BALLARD'S PAPER

Robert L. Brunet, of Providence, R. I., in a written discussion, said that with low rates for energy the load factor of 40 per cent. would possibly be realized based on a peak of 18,000 kw., but when the peak of 18,000 kw. is reached the generating equipment will undoubtedly have to be increased to insure reliability and continuity of service. He has found that the income per $1 of investment varies from 20 per cent. to 25 per cent. in most private plants, while Mr. Ballard has estimated an income of 33 per cent. per $1 of the investment.

James R. Cravath, of Chicago, said that it would have to be demonstrated whether the estimated maximum load of 18,000 kw. could be brought to the Cleveland station with a distribution cost low enough to bring the total investment in power-plant and distribution systems to but $3,000,000. It is possible by cultivating the large motor-service business and ignoring the low-load-factor lighting business, such as residences and early-closing stores, that a 40 per cent. load factor might be maintained from the start. The natural tendency of rates as low as those given would be to load up the plant with low-load-factor business unless care was exercised to prevent it.

Alex Dow, president of the Detroit Edison Co., said that he had followed the construction and operation of the plant with interest; that the plant was a good one, a credit to Mr. Ballard, to the consulting engineer and to the city officers who let them go ahead and make a good plant. He said that what Mr. Ballard needed first was a distributing system, which he has not, and, second, a load, which he has not, and, third, the keeping of accounts in a manner acceptable to a public service commission. Mr. Dow was of the opinion that there was nothing radical in the station, inasmuch as it contained apparatus practically the same as that in the Delray Station.

Reginald Pelham Bolton, of New York, said that the rates are such as to offer little inducement to those consumers whose business is most desirable in producing a high load factor and that this rate does not include any service charge and is drawn merely on the relation of connected capacity and monthly consumption. He wanted to know if there were any data in the paper which justified the expectation that the small consumer can be served at the rate of 3c. per kw.-hr. without loss, which must be borne by other consumers or by a deficit in operation.

Mr. Ballard, in his response, said that he was delighted to learn that Mr. Dow did not consider that there was anything at all radical in the Cleveland station. He admitted it was true that everything in the station is the same as at

the Delray plant, and inasmuch as this is so there was no reason why the Delray Station should not sell its current at the same price at which the Cleveland plant was selling it; and he hoped to see them do it. Regarding station rating, Mr. Ballard's understanding was that stations at the present time are generally rated at their maximum capacity for a 24-hr. service indefinitely. Tests show that the turbines in the Cleveland plant are capable of 7500-kw. continuous capacity, three giving 22,500 kw. and the 1500-kw. auxiliary machine bringing the total maximum capacity to 24,000 kw. Upon these figures his statements were based. In regard to capacity, in answer to Mr. Cravath's discussion of the 40 per cent. load factor, Mr. Ballard said: "I find it is not difficult for us to get a 40 per cent. load factor—to get it and to average it. We are running along every day between 60 and 80 per cent. load factor. As we build up the load on our stations we will probably secure a much lower power factor than that. We may go down to 40 per cent., but I hope we will not go below that."

Regarding the cost per kilowatt-hour being different for different customers, Mr. Ballard admitted that the plant was radical in that respect, saying: "Outside the question of competition, if there was only one station in the city and every customer had to take its terms or have none at all, you could not make one figure and a uniform load. You could not sell current to all your small resident customers at as low a rate as you would want to sell it to your power customers. On the other hand, you could not charge your power customers at a higher rate than your resident customers. If you did you could not get the business. That is not necessarily following out the plan of the National Electric Light Association of charging all that the service will bear. If you can sell current to large power companies at 1c. you are selling to the majority of them for less than one-half of what they can make it themselves."

Automatic Reclosing Circuit-Breaker*

BY E. C. RANEY

In the application of protective apparatus to the power circuits of industrial plants there are four conditions which should be fulfilled:

1. The current must be quickly interrupted in case of short-circuit or excessive overload.
2. The circuit should not be closed while the short-circuit still exists.
3. To avoid unnecessary delay the circuit should be closed instantly upon the removal of the short-circuit.
4. For the protection of motors on the circuit, power should not be restored until the controllers or starting-box levers have been moved to the "starting position."

The first of the above conditions may be met by placing either a fuse or a hand-operated circuit-breaker in the circuit to be protected. It will be readily seen, however, that the remaining conditions are difficult to meet by either the hand-operated breaker or the fuse, in cases where the line is of considerable length and the load is not in sight of the attendant.

These difficulties were forcibly brought to the writer's attention while in charge of power plants for mine work and while a motor inspector in steel mills. At that time there was no protective device on the market which met all four conditions, and it was the necessity for such a device which led the writer into the work of its development. The automatic reclosing circuit-breaker, here described, is the result of these efforts up to the present time.

THEORY

In order to make a circuit-breaker which will automatically reset after the overload condition has been removed, it is required that a shunt circuit with a resistance be provided around the main contacts, so that after the main contacts are open there may still be a small amount of current to act as an index to the condition of the line. The reclosing mechanism must be responsive to variation in this index current, which variation must be caused by the increase of resistance of the load or short-circuit. For example, take the case of the circuit-breaker on a 250-volt circuit, set at 500 amp. When the load resistance becomes such that more than 500 amp. will flow, this resistance will be

$$R = \frac{E}{I} = \frac{250}{500} = 0.5 \text{ ohm or less}$$

In case of a short-circuit the resistance of the load becomes practically zero and the breaker must be so constructed that it will not reclose while the load resistance is less than 0.5 ohm. Since in practical circuits it is always permissible to have lights or a constant load connected to circuit, the breaker should be capable of reclosing whenever the load resistance has reached a value slightly above that which caused the breaker to open. Assume that the constant load is 250 amp. and the motor load 250 amp. in the foregoing example. The load resistance will then never be greater than 1 ohm, which will require that the breaker shall not close on a load resistance of less than 0.5 ohm, but will reclose before the resistance has been increased to 1 ohm. In other words, the reclosing mechanism must be sensitive enough to respond to a change of resistance of less than 0.5 ohm in the load circuit.

The resistance of the shunt circuit around the breaker must be 125 ohms, if 2 amp. is allowed to flow at 250 volts on short-circuit as an index current. In commercial circuits the voltage variation is likely to be 10 per cent. or more, which means that the current variation through the 125-ohm shunt may be 10 per cent. of 2, or 0.2 amp. due to that cause alone. The variation of current in the shunt circuit resistance, caused by the load resistance being increased from 0 to 1 ohm, will be

$$2 - \frac{250}{126} = 0.096 \text{ amp.}$$

which is less than the variation due to permissible voltage variation.

It was this consideration which led to the adoption of the shunt circuit used in the present breaker, where two paths are provided for the current after passing through the load. In a branch circuit carrying a definite amount of current,

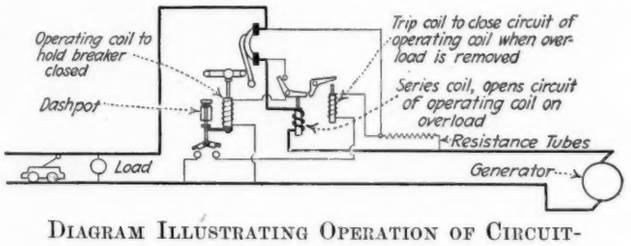

Operating coil to hold breaker closed
Dashpot
Trip coil to close circuit of operating coil when overload is removed
Series coil, opens circuit of operating coil on overload
Resistance Tubes
Load
Generator

DIAGRAM ILLUSTRATING OPERATION OF CIRCUIT-BREAKER

the latter divides in the two branches inversely proportional to their respective resistances. When the load resistance is practically zero, on account of a short-circuit, nearly all the current flowing through the shunt resistance passes through the load circuit; but when the short-circuit is removed and the load resistance is increased to 1 ohm, if the load resistance coil has 1 ohm, then the current will be equally divided in the two branches and the current variation in the coil will be from 0 to 1 amp., which may be made enough to operate a relay setting the reclosing mechanism into operation.

OPERATION

Referring to the diagram, Fig. 1, it will be seen that the main contact brush is moved to the closed position and is held closed by the operating coil. The main load current passes through a series coil and main contacts. In case of an overload current in the series coil, its armature or core is raised and opens a contact which breaks the circuit of the operating magnet and allows the breaker to open.

The contact arm controlling the current in the operating coil is now held open by a latch until the trip coil operates to release the latch. After the opening of the main contact a small current is permitted to flow around the breaker through a high resistance. This current has two paths leading to the line of opposite polarity, one path around the breaker and through the load, and the other through the trip coil and the dashpot bridge. So long as there is a short-circuit or low resistance on the load circuit, this index current will be shunted past the trip coil, but whenever the short-circuit is removed or the load resistance is increased to a certain amount, enough current will be forced through the trip coil to operate the latch and allow the contact arm to again close the circuit of the operating coil. The breaker is then instantly closed by this action.

A dashpot is provided to prevent the breaker from closing instantly after being opened by a momentary overload. The object of this is to give sufficient time for motors to come to rest and for starting-box levers to be moved to starting position before the breaker recloses, regardless of the cause of the opening.

Briefly stated, the action is as follows: The breaker opens in case of either an overload or short-circuit, and remains

*From a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers.

open a few seconds in either case. At the expiration of this time limit, it closes, provided the overload condition has been removed; it remains open so long as a short-circuit exists and closes instantly upon its removal.

Recent Court Decisions

Digested by A. L. H. STREET

Electric Power as a "Municipal Purpose"—Provision in an electric power company's franchise granted by a city requiring the company to furnish power to the city for "municipal purposes," on certain terms, extends to the furnishing of current to operate an electric-light plant. (Colorado Supreme Court, City of Colorado Springs vs. Pike's Peak Hydro-Electric Co., 140 "Pacific Reporter," 921.)

Assumption of Risk by Engineer—An engineer in a stationary plant assumes the risk of falling into a pit after another employee has left the trapdoor covering it open, where he knows that it is apt to be open any time, according to the holding of the Massachusetts Supreme Judicial Court in the late case of Burnett vs. Worcester Brewing Corporation, 106 "Northeastern Reporter," 597.

Validity of Condemnation Statute—In a proceeding by an electric power company to condemn land for use of the company, under the laws of Tennessee, which restrict the right of condemnation to corporations, the landowner cannot question the validity of such laws on the ground that they constitute an unjust discrimination against individuals and partnerships who are not accorded the right of condemnation, since he is not injuriously affected by any such discrimination that may exist. (Tennessee Supreme Court, Noell vs. Tennessee Eastern Power Co., 169 "Southwestern Reporter," 1169.)

Right of Power Company to Condemn Land—In a decision announced by the Minnesota Supreme Court, the Minnesota Canal & Power Co. is denied the right to condemn land for one of its projects, on the ground that the enterprise could not be accomplished without impairing the navigability of the waters of the Birch Lake drainage basin. The court holds that a power company, or other public service corporation, cannot divert water from the navigable streams of one drainage basin into those of another basin, if the diversion impairs the navigability of the former; and that private property can be condemned only when the condemnation subserves some lawful public use.

Extent of "Water Power" Rights.—"Horsepower" Judicially Defined—When the right is granted to use the water of a canal or stream for the development of "water power," the grantee acquires no right to use the water for any purpose other than the propulsion of machinery; no water may be diverted or consumed for condensation purposes. This point was recently decided by the Pennsylvania Supreme Court in the case of the Eastern Pennsylvania Power Co. vs. Lehigh Coal & Navigation Co., 92 "Atlantic Reporter," 47. Referring to the term "horsepower," the court finds that it "has in popular acceptation a fixed, definite meaning. As originally employed it expressed the power of a steam engine. It has come to mean the unit in estimating the power required to drive machinery."

What Constitutes a "Stationary Steam Engine?"—Is a steam engine, which has been set upon a concrete foundation and so bolted and braced as to be free from vibration and which is used in quarrying rock and may be so used for two or three years, a stationary engine within the meaning of an ordinance prohibiting operation of stationary steam engines within certain limits in a city without first obtaining a license? This question, which was recently presented to the Massachusetts Supreme Judicial Court in the case of McDonough vs. Almy, 105 "Northeastern Reporter" 1012, was answered by that court in the affirmative. Justice Crosby said, in announcing the decision: "Whatever may have been the character of the engine when it was brought to the plaintiff's land, we have no doubt that when it was set upon the concrete foundation and permanently attached thereto for the purpose of being used two or three years, it became a 'stationary steam engine' within the meaning of the ordinance."

Remedy for Breach of Contract—According to the decision of the West Virginia Supreme Court of Appeals in the case of United Fuel Gas Co. vs. West Virginia Paving & Pressed Brick Co., 82 "Southeastern Reporter," 329, suit will not lie to enjoin a manufacturer from breaking a contract to buy fuel from plaintiff exclusively for a certain period. The court holds that the fuel company's only remedy is a suit to recover damages for breach of the contract. The defendant agreed to purchase from the plaintiff, for a period of three years, all the natural gas it should use in its manufacturing plant, and to pay for the same monthly at certain prices per thousand feet, graduated according to the quantity used. About the middle of the term the defendant purchased natural gas from another gas company and ceased using the plaintiff's product, whereupon the plaintiff applied for an injunction to restrain the defendant from purchasing gas from the other company during the term of the contract.

Effect of Power Rate Ordinance on Existing Contracts—When a consumer of electrical power makes a contract with a public service corporation for service, the parties are conclusively presumed to have contracted in contemplation of the power of the proper public authorities to fix rates, according to a decision handed down the other day by the Supreme Court of California in the case of Pinney & Boyle vs. Los Angeles Gas & Electric Corporation, 141 "Pacific Reporter," 620. The effect of this decision is to nullify the contract rate on a higher or lower rate being established by public authority. Plaintiff used electrical power to operate its machinery, and made a contract with defendant for future service. During the life of the contract, the city of Los Angeles adopted an ordinance fixing a schedule of rates which was higher for the service involved than that fixed by the contract, and the defendant declined to furnish service at the contract rate. The decision of the Supreme Court upholds the defendant's position and overrules the plaintiff's contention that the ordinance is invalid.

Power of Traction Engines—When a contract for the sale of a traction engine contains a warranty on the part of the seller that the engine will develop a certain horsepower, but does not specify whether the power is to be developed at the belt or at the drawbar, the transaction will be governed by a trade custom placing an interpretation on the point, according to a late decision of the Texas Court of Civil Appeals in the case of Southern Gas & Gasoline Engine Co. vs. Adams & Peters, 169 "Southwestern Reporter," 1143. Under the evidence in this case, such a contract is held to be properly interpreted under a trade custom requiring the rated horsepower to be developed at the drawbar. Referring to the rule of law that the provisions of a written contract cannot be varied by showing oral conversations or trade customs which are clearly inconsistent with such provisions, the court said:

It is not varying the terms of a written instrument to explain what is meant by a term used therein, especially a scientific or trade term which is not generally understood. Here we have the written instrument merely stating that the engine is to develop 20 hp. It is nowhere stated that it is to develop that power at the belt or drawbar, and the only way a layman could understand the term would be by proof as to what is meant by such a term. If it had stated that the power should be tested at the drawbar or belt, there could be no question that oral evidence could not be introduced which would tend to vary the writing. But parol evidence is admissible to aid in the interpretation of a scientific or trade term.

Another Feeder Accident in Cleveland

The municipal lighting plant at Cleveland celebrated the end of the year by a short-circuit in an overhead feeder leading out of the West 41st St. substation, which is the distribution center for the part of the city bounded by Lake Erie, West 65th St., Brooklyn and west of the Cuyahoga River. The trouble started about 8 p.m. on Dec. 31, and service was not restored till after midnight. It is stated that the cause of the trouble was a short-circuit in changing over feeders to consumers who formerly were served from the South Brooklyn plant to the new plant on East 53d St. In the area within which service was cut off, several hospitals reverted to oil lamps or gas, street lights were out and a number of moving-picture shows had to suspend operations.

Long Southern Electric Transmission

The Tennessee Power Co.'s Sequatchie Valley transmission line was completed about the middle of last December. Electric current was then turned on from the $10,000,000 power plant at Hale's Bar (of which the Tennessee Power Co. is now the largest customer) to both of the three-phase conductor circuits.

Although the generators have been connected to the transmission line since last August, only one of the three-phase circuits had been in full working order until mid-December. The transmission line is one of the most permanently constructed in the South and the longest line of the kind, voltage capacity considered, in that part of the United States.

College, the village at which the Brady power plant is connected with the Ocoee-Nashville line, is about 36 miles

from Hale's Bar on the Tennesseee River. The voltage capacity of the connecting line is 120,000, or nearly double that of the line from the two Ocoee plants to Chattanooga and Knoxville.

The two circuits, each three-phase, consist of six heavy aluminum cables. One circuit is of 250,000 and the other of 400,000 circ. mils area. At Hale's Bar the Tennessee River is spanned by a 2331-ft. stretch of steel-core aluminum cables of ⅞-in. diameter, suspended between four steel towers 60 ft. high. The towers are set on high elevations so that the cables are 115 ft. above the water. There are 435 galvanized steel towers supporting the double circuit between Hale's Bar and College, the towers being spaced at intervals averaging 453 ft. The tops of the towers are connected with a ⅜-in. ground wire.

The insulators of the high-powered cables are the suspension-type porcelain disks, eight units to each insulator, except at the river crossing, where specially constructed insulators are used to support the heavy span. They are made of treated wood strips inclosed in oil-filled porcelain shells, the largest of the kind ever made; no others like them are in use. The first and eighth disks are 6½ ft. apart, and the mechanism holds the cable 12 ft. from the steel tower's supporting arm.

OBITUARY

JOHN McDONALD

John McDonald, an engineer well known locally and in the N. A. S. E., died of heart failure at his home in Ludlow, Vt., Dec. 17, 1914. He was 63 years of age. The greater part of his life was spent in engineering work.

ENGINEERING AFFAIRS

Award of the John Scott Medal—The city of Philadelphia, acting on the recommendation of The Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Arthur Atwater Kent, of Rosemont, Penn., for his "Unisparker," an essential element of the Atwater Kent ignition system for automobiles, consisting of a contact breaker, governor and distributor, in one structure, and to Elmer Ambrose Sperry, of New York, N. Y., for his gyro-compass.

On battleships under action, the shifting of large masses of magnetic material precludes the use of the magnetic compass, and even on ordinary iron vessels, the material of the ship and its disposition must be compensated for. The gyro-compass is entirely nonmagnetic and is unaffected by the proximity of iron.

The Engineering Foundation—A noteworthy incident in the history of the profession of engineering in the United States will be the inauguration of The Engineering Foundation on Jan. 27, 1915, in the auditorium of the United Engineering Society in New York. The Engineering Foundation is a fund to be administered for the advancement of the arts and sciences connected with engineering and the benefit of mankind, the basis of which is the initial gift of a considerable sum by a noted engineer for this purpose. The American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers are to be represented equally in the administrative Board of The Engineering Foundation by election by the Board of Trustees of the United Engineering Society, which had been made the custodian of the fund. All members and friends of the engineering profession are invited to these inaugural ceremonies.

TRADE CATALOGS

Massey Machine Co., Watertown, N. Y. Catalog No. 7. Governors, Class M. Illustrated, 16 pp., 6x9 in.

Watson-Stillman Co., Aldene, N. J. Booklet. Kromax leather packings. Illustrated, 16 pp., 3½x6 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-S. Small power driven compressors. Illustrated, 16 pp., 6x9 in.

Neil & Smith Electric Tool Co., Cincinnati, O. Catalog No. 4. Portable electric drills, buffers, grinders, screwdrivers, etc. Illustrated, 56 pp., 6x9 in.

BUSINESS ITEMS

The Cling-Surface Co., of Buffalo, N. Y., has prepared a special calendar for members of the N. A. S. E., copies of which it will gladly mail free on request as long as the supply lasts.

The Lagonda Mfg. Co., Springfield, Ohio, has just published a new 32-page booklet on the Lagonda Boiler Tube Cleaners. It is called catalog L-8—contains many illustrations showing details of construction and also cleaners in actual use, and copies are mailed on request.

The New York office of the Kerr Turbine Co., Wellsville, N. Y., will hereafter be located in Room 801, Singer Bldg. Annex. Mr. Benjamin G. Fernald has been appointed district manager. Mr. Lawrence G. Hanmer will continue to be associated with the New York office and arrangements have been made for prompt and effective attention to all inquiries.

The Files Engineering Co., of Providence, steam specialists and engineers, have established a branch office at 120 Kossuth St., Bridgeport, Conn., where they will contract for power, heating, drying, evaporating and steam specialty work of every description. They request catalogs and other literature descriptive of apparatus and appliances relating to these lines sent to their Bridgeport office.

"Cochrane Multiport Vales," a booklet of 72 pages, just issued by the Harrison Safety Boiler Works, 17th and Clearfield St., Philadelphia, Penn., describes the multiport valves introduced by that concern for back-pressure, relief and vacuum service, flow service in connection with mixed flow turbines, and check-valve service with bleeder or extraction turbines. In addition to full descriptive and tabular matter, the book contains numerous diagrams and layouts, also data on the effects of air in condensers and upon turbine performance.

A booklet worth having is the new booklet issued by the United States Graphite Co., Saginaw, Mich., on the subject "U. S. G. Co.'s Mexican Graphite Paint—Its Uses and Users." It is an excellent booklet from the standpoint of printing as well as subject matter. Fine halftones are used throughout, illustrating many buildings, bridges, etc., where the paint was used. Complete details are given about graphite, the care used in making the paint, and the "reasons why" it should be used. And letters are used to show what success users have had with it. It's a 64-page booklet and is sent on request to anyone interested in graphite paint.

Among recent sales of Bruce-Macbeth gas engines, made by the Bruce-Macbeth Engine Co., Cleveland, Ohio, are the following: Magnolia Pipe Line Co., Fort Worth, Tex., two 150-hp. natural gas engines; Thompson Milling Co., Lockport, N. Y., one 350-hp. natural gas engine; Village of Wellington, Ohio, for municipal lighting plant, one 125-hp. natural gas engine; Kloss Ice Cream Co., Wheeling, W. Va., one 90-hp. natural gas engine; Broadway Market Co., Detroit, Mich., one 90-hp. artificial gas engine; one 70-hp. two-cylinder natural gas engine to J. K. Mosser Co., Parsons, W. Va.; one 150-hp. four-cylinder natural gas engine to Victor Auto Parts Co., Cincinnati, Ohio; one 70-hp. two-cylinder natural gas engine to the Willson Ave. Lumber Co., Cleveland; one 150-hp. four-cylinder natural gas engine to Chisholm Steel Shovel Works, Cleveland, Ohio.

The annual report of the Northern Equipment Co., Erie, Penn., manufacturer of the Copes boiler feed water regulator and the Cope pump governor, shows that 1914 was the greatest year in the history of its business. Its sales exceeded its next best year by 9½%. Larger quarters have again become necessary, and in order to provide this it has purchased the plant, equipment and business of the Erie Pump & Engine Works. The new plant is located in the heart of the city and affords excellent shipping facilities. Mr. J. H. Dougherty, formerly with the International Steam Pump Co., has been engaged to take charge of centrifugal pump design, and the well known line of Erie centrifugals is to be improved and extended. A consolidation of the two companies is being perfected and the new combination will be known as the Erie Pump & Equipment Co. The officers of the new company are: E. W. Nick, president and treasurer; D. H. DuMond, vice-president; V. V. Veenschoten, secretary. Mr. John G. Pfadt, former president of the Erie Pump & Engine Works, is not connected with the new company.

CONTRACTS TO BE LET

TREASURY DEPARTMENT, Supervising Architect's Office, Washington, D. C., January 5, 1915.—Plans and specifications are now approaching completion for a central heating, lighting and power plant, to be erected in this city under the direction of this office. These plans and specifications will be ready for delivery on or after January 15. Bids may be submitted for the entire work or for any one of the following sections: Power plant building complete, with steel stacks; boilers; generating apparatus; pumping equipment; condensers; coal and ash handling apparatus; steam and water piping; switching gear; tunnels; substation apparatus, etc. Prospective bidders should immediately submit to this office applications for plans and specifications, stating the portions of the work upon which they desire to bid. If it appears that the applicant is in a position to bid on all of the work in any one of the sections of the project, or upon the entire work, the plans and specifications will be forwarded. No plans or specifications will be furnished sub-bidders or others not in a position to submit a bid on all of the work comprised in at least one section. The Department will be able to allow only about 15 days for the preparation of estimates. At the time plans and specifications are forwarded to bidders the date for the opening of bids will be stated, and this date will not be extended. O. WENDEROTH, Supervising Architect.